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UNION OF SOUTH AFRICA

DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES

INVESTIGATIONAL REPORT No. 24

THE SOUTH AFRICAN PILCHARD

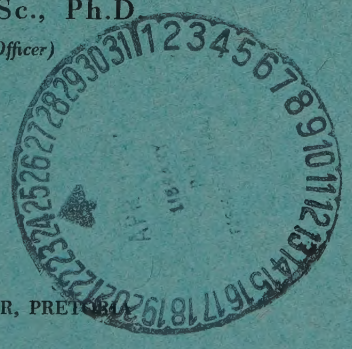
(Sardinops ocellata)

MIGRATION, 1950-55

BY

D. H. DAVIES, M.Sc., Ph.D.

(Senior Professional Officer)



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1. SUMMARY.

The purpose of this investigational report has been to extract and review all available data in any way connected with the movement of pilchards, with the object of providing some explanation of local movement and migration. In addition, the possible relationship between the pilchards of Walvis Bay, St. Helena Bay, False Bay and the Natal coast has been considered.

The problem of the migration of the South African pilchard will be finally solved only by tagging, but as a result of this investigation the following findings have been made:—

(1) Pilchards are present in greatest abundance in the St. Helena Bay area from March to July each year.

(2) The pilchard shoals of the St. Helena Bay area migrate offshore from August through spring and early summer each year for purposes of spawning. This migration takes the form of successive departures of individual shoals and no mass migration takes place.

(3) Pilchards return to St. Helena Bay towards the end of January.

(4) The presence of feeding pilchard shoals in abundance in the St. Helena Bay area during the period March to August together with a decrease in nutrients due to decreased upwelling has the effect of reducing the volume of edible plankton in a most marked manner.

(5) As indicated by records of recently spawned ova, pilchards may be dispersed over a very wide area particularly during the spring and summer months.

(6) There is no *apparent* relationship between the presence of pilchards in St. Helena Bay and water temperature.

(7) There is a direct relationship between the total catches of pilchards in St. Helena Bay and wind. During the summer when the incidence of southerly winds is highest and velocities are high, pilchard catches are poorest and during winter when most winds come from the north and velocities are low, commercial catches are high. During summer and autumn when the incidence of southerly winds is high, commercial catches are generally made offshore. During winter and early spring when the incidence of southerly winds is low, commercial catches are generally made close inshore.

(8) Important records showing the wide dispersal of pilchards at certain times were obtained from the examination of the stomachs of predatory fish.

(9) A comparison of the vertebral counts of pilchards caught in various areas showed no apparent racial differences.

(10) A comparison of the size composition of pilchards caught in various areas showed that, in general, small, mainly sexually immature pilchards are concentrated on the South and East coasts and mainly sexually mature fish in the West coast region of St. Helena Bay. At Walvis Bay pilchards are smaller than those from St. Helena Bay and a proportion probably immature.

(11) The areas of Walvis Bay and St. Helena Bay, because of their high productivity and the shelter which they provide, are important feeding areas for pilchards during the non-spawning season.

(12) A general hypothesis on the migration of the pilchard is discussed.

2. INTRODUCTION.

One of the most important aspects of the general biology of the South African pilchard is migration. In the South West African fishery a catch of 250,000 tons of pilchards is made annually and in the pilchard fishery of the Union of South Africa a further 250,000 tons are caught annually. In Natal a very small catch, estimated at under 100 tons, is made in the month of June during most years.

Although the distribution of *Sardinops ocellata* (see Fig. 1) extends from Baia dos Tigres on the West coast round the Cape of Good Hope to Durban on the East coast, a distance of over 2,000 miles, large concentrations of pilchards are found at Walvis Bay and St. Helena Bay and to some extent off the coast of Angola.

According to the F.A.O. Yearbook of Fishery Statistics (1955), Angola produced 25,795 tons of pilchards during 1954. These were presumably derived from catches made in the area of Baia dos Tigres and landed at Mossamedes. Vilela (1923), wrote as follows about the pilchard: "Aparece só na costa dos Tigres, entrando em abundancia dentro da Baia, de Julho a Outubro e mesmo ate Janeiro." He gave the name as *Clupea sagax* Gunther and Gilchrist's figure (1913)

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and the size range as 15-20 cm. There can be no doubt that this reference was to *Sardinops ocellata.* No more recent reference to pilchards off Angola has so far been obtained, but the F.A.O. statistics reveal the important fact that an industry of considerable size based on comparatively small-sized pilchards is in existence. If the pilchard populations of Angolan, South West African and South African waters are found to be related, effective control of the fishery will be an international matter.

The occurrence of large numbers of pilchards off Natal is limited to a short period in the month of June each year and it is unlikely that commercial exploitation on a large scale would be worth while.

In spite of this wide distribution, concentrations of pilchards occur only in these limited areas and it is this that enables such intensive commercial exploitation to take place. It is therefore of fundamental importance to ascertain whether these concentrations comprise separate populations or whether the pilchards of Angola, South West Africa, St. Helena Bay and Natal are connected.

The final answer will doubtless be provided by the results of an extensive tagging programme. Up till now, however, so much energy has been devoted to other aspects of pilchard research, that it has not been possible to carry out any tagging other than preliminary experimental work.

The main object of this paper has been to review briefly all the data at present available which might throw any light on the movements of the pilchard and to provide a workable hypothesis which may be later confirmed or otherwise by the results of tagging.

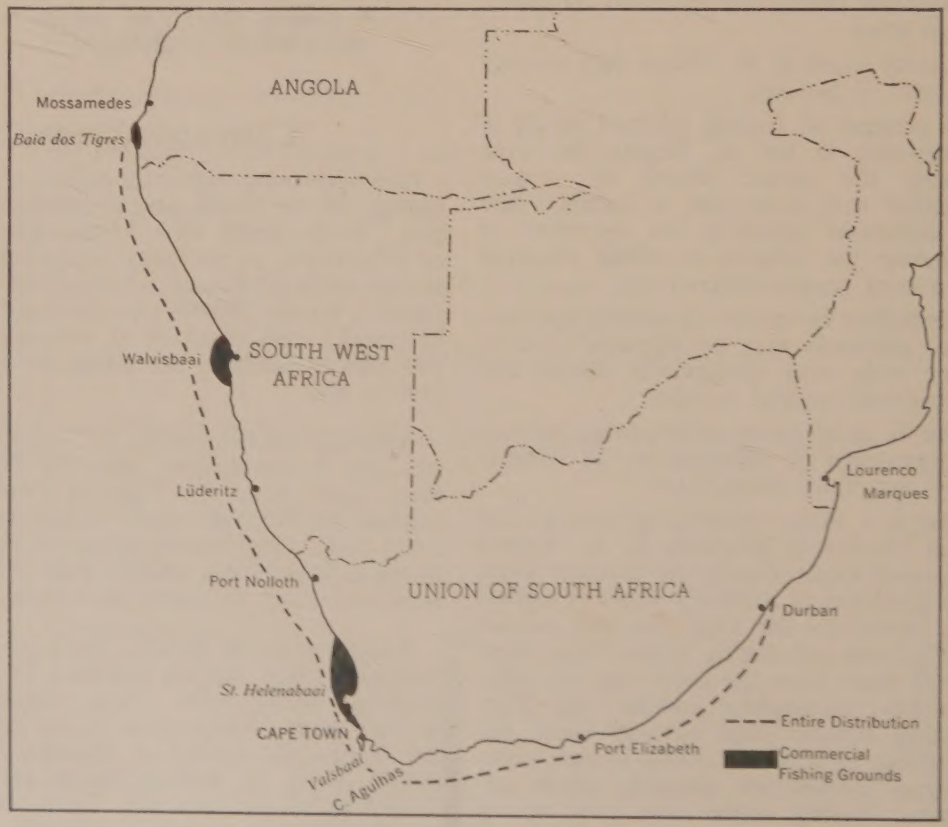

FIG. 1 DISTRIBUTION OF THE SOUTH AFRICAN PILCHARD

Trigsurvey, 1956. Government Printer, 1956.

Data on the movements of the pilchard have been collected from many sources, including the records of the positions of commercial catches in Union waters, the presence of pilchards in the stomachs of predatory seabirds and fish, the comparison of vertebral counts of pilchards from different areas and the comparison of the sizes of commercial catches by means of length frequencies. Finally, an attempt has been made to explain the movements of pilchards by linking them up with factors such as the availability of food (plankton density), spawning and environmental factors such as temperatures and winds.

For purposes of convenience and clarity, the pilchard fishing grounds off the West coast of the Union of South Africa have been divided into three areas (see Plate 1). These areas are as follows:—

(1) *The Northern area* extending from a point approximately 10 miles south of Island Point to Donkin Bay and up to 10 miles from the coast.

Comparatively few catches are made in this area and fishing generally takes place within 5 miles of the shore.

(2) *The St. Helena Bay area* extending from Donkin Bay to Cape Columbine and up to 35 miles from the coast.

The vast majority of commercial catches are made in this area.

(3) *The Southern area* extending from Cape Columbine to Cape Town and up to 25 miles from the coast.

Few catches are made in this area when compared with those of the St. Helena Bay area but catches made off Saldanha Bay and in the vicinity of Dassen and Robben Islands may be frequent especially when fish are scarce in the other areas.

3. THE RELATIONSHIP BETWEEN COMMERCIAL CATCH POSITIONS AND THE MOVEMENT OF PILCHARDS.

(*a*) Commercial Catch Positions, 1950-55.

Since the time when sampling first started in March, 1950, the positions of the commercial catches of pilchards from which samples were taken were recorded. For the period March, 1950, to December, 1952, the commercial catches were sampled from two shore stations, Lambert's Bay and Stompneus Bay (see Plate 13), but from January, 1953, to December, 1955, samples were taken at Stompneus Bay only. For the first period therefore a broader picture of the distribution of catches was obtained due to the fact that the boats naturally make their catches as near as possible to their home port. The same general seasonal trends of movement were, however, found throughout the entire period.

The commercial catch positions were plotted for each season from autumn, 1950, to spring, 1955 (see Plates 1-6). For easy reference a table has been prepared which summarises the catch positions for each season (see Table 1).

This shows that the positions of the commercial catches of pilchards undergo considerable variation. In order to determine this variation with greater accuracy the movement of catch positions was divided broadly into two categories:—

(i) Onshore and offshore movement.
(ii) North and south movement.

(i) Onshore and Offshore Movement.

In order to establish the extent of this movement the commercial fishing areas were divided into the following zones:—

(1) From the shore to 5 nautical miles offshore (0-5 n.m.).
(2) From the shore to 10 nautical miles offshore (0-10 n.m.).
(3) From the shore to 20 nautical miles offshore (0-20 n.m.).
(4) From the shore to over 20 nautical miles offshore (over 20 n.m.).
(5) From 5-10 nautical miles offshore (5-10 n.m.).
(6) Over 10 nautical miles offshore (over 10 n.m.).

For the years 1953-55 the numbers of commercial catch positions in these zones were counted for each month and the means for the three years expressed as percentages (see Table 2 and Plate 8).

These data showed the following:—

During December no data were available due to the absence of pilchards in the area and the closed season.

In January, inshore catches were frequent but at the same time catches made 5-10 n. miles and over 10 n. miles offshore were numerous, showing a dispersal of fish from close inshore to offshore.

In February the numbers of inshore (0-5 n.m.) catches declined and the number of 5–10 n. miles catches increased showing an offshore movement.

During the autumn months of March, April and May inshore (0-5 n.m.) catches were reduced in number while the numbers of 5-10

n. miles and over 10 n. miles catches had increased showing a definite offshore movement. Before the end of autumn, however, the numbers of inshore catches had begun to increase and the over 10 n. miles offshore catches to decline. The 5-10 n. miles catches continued to increase until May, showing that an inshore movement had begun from the over 10 n. miles offshore to the 5-10 n. miles area.

During the winter months of June and July the inshore (0-5 n.m.) catches were at a maximum, the 5-10 n. miles catches had shown a considerable decline and the over 10 n. miles catches were at a minimum, showing that the majority of pilchards were close inshore. In August the numbers of inshore catches declined and the 5-10 n. miles and the over 10 n. miles catches increased showing the start of an offshore movement.

In the spring months of September, October and November the numbers of inshore catches remained constant at fifty per cent, the 5-10 n. miles offshore catches fell rapidly to nil in November and the over 10 n. miles offshore catches rose just as rapidly from nil in September to fifty per cent in November. This showed that while large numbers of shoals remained close inshore, similar numbers were over 10 n. miles offshore. When this is considered with the fact that the numbers of pilchards decline during this period (see Plate 11, Fig 1) it is evident that this offshore movement is associated with the spawning migration.

Data collected over the longer period from 1950 to 1955 were treated on a seasonal basis as monthly analyses during the years 1950-52 were not available. These seasonal data were analysed in relation to the four zones, 0-5 n. miles., 0-10 n. miles., 0-20 n. miles and over 20 n. miles offshore and the number of records of commercial catches expressed as percentage frequencies of occurrence (see Table 3). Graphical representation of these data for catches recorded close inshore, 0-5 n. miles (see Plate 9) showed the following:—

(1) That there was a similar variation in the seasonal occurrence of catches close inshore during all years except 1951.

(2) This variation showed the same general trends as the 1953-55 analysis on a monthly basis (see Table 2 and Plate 8), with the exception of 1951.

(3) The variation showed that a fair number (22 i.e. 50 per cent) of commercial catches were made close inshore in summer, the lowest number (8 i.e. 34 per cent) in autumn, the largest number (44 i.e. 85 per cent) in winter and considerable numbers (42 i.e. 76 per cent) in spring.

The year 1951 was different from the other years in that large numbers of catches (68 per cent) were recorded inshore in autumn whereas the least numbers were recorded in this season for the other years.

From the Table (Table 3) it is seen that the catches made farthest offshore were recorded in autumn, 1952, winter, 1953, and autumn, 1955. The farthest catch was 31 n. miles offshore.

Seasonal means of the data from Table 3 were calculated (see Table 4) and plotted for the zones 0-5 n. miles, 0-10 n. miles offshore, 5-10 n. miles and over 10 n.m. from the shore (see Plate 10). This showed the general tendency for a low incidence (approximately 30 per cent) of catches close inshore during summer and autumn, a sharp increase to a maximum of catches close inshore in winter and a continuation of this maximum through to spring. A similar trend was shown for catches recorded in the 0-10 n. miles catches.

The catches within 5-10 n. miles of the shore showed a generally inverse relationship with the inshore (0-5 n.m.) catches and the over 10 n. miles offshore varied in a similar manner to the 5-10 n. miles catches. In summer catches were distributed from close inshore through to five, ten miles and farther offshore. In autumn the majority of catches were in the area 5-10 n. miles offshore but in winter catches were predominantly inshore. In spring most catches were inshore but a definite offshore movement was evident.

A summing up of the onshore and offshore movement is given as follows:—

SUMMER—*pilchards are generally absent or rare in the St. Helena Bay area during December and rare in early January. In late January or early February pilchards appear close inshore and offshore. Later in February larger numbers appear offshore.*

AUTUMN—*in March the lowest number of pilchards are found inshore and the greatest number are found over* 10 *n. miles offshore. In April inshore catches are still low and* 5-10 *n. miles offshore catches increase indicating the start of an inshore movement. In May inshore catches increase and* 5-10 *n. miles offshore catches reach a maximum showing the further increased tempo of the inshore movement.*

WINTER—*in June and July the maximum number of catches close inshore occurs with a corresponding minimum of offshore catches. In August a decline in the numbers of inshore catches begins together with an increase in* 5-10 *n. miles and over* 10 *n. miles offshore catches, showing the beginning of the offshore migration.*

SPRING—*in September, October and November inshore catches remain high but the following changes take place in the offshore catches: in September* 5-10 *n. miles offshore catches are very high and over* 10 *n. miles offshore nil; in October* 5-10 *n. miles offshore catches decline to nil in November; in October over* 10 *n. miles offshore catches increase rapidly and reach a maximum in November. This indicates a very definite offshore movement which takes place during the Spring months but does not entail the movement of the entire population.*

(ii) North and South Movement.

In order to determine the seasonal movement of pilchard shoals along the West coast, commercial catch positions for each season from 1950 to 1955 were examined in relation to the three main areas of commercial fishing, the Northern Area, the St. Helena Bay Area and the Southern Area (see Plate 1).

Each area was then subdivided into a number of sub-areas in such a way that a good coverage of each main area was obtained.

The total number of catches made per season in each main area was counted, and the density of catches in each sub-area determined as follows:—

A celluloid sheet marked in squares 10 by 10 square nautical miles in size was placed at a definite point in each sub-area, for example, at Cape Deseada the middle of one side of the square was placed over the point of Cape Deseada, and the number of commercial catch positions falling within the square was counted. This figure was then used to indicate the catch density in numbers of catches per square of 10 square n. miles.

Only four per cent (32) *of the total number of commercial catches for the period* 1950-55 *occurred in the Northern Area* (see Table 5). Within this area average catch densities were low at the southern sub-area of Donkin Bay due partly to the fact that some of the catches made were to the south of Donkin Bay and were therefore included in the figures for the St. Helena Bay Area (see Table 6). At the central sub-area of Olifants River average catch densities were a little higher (4 catches per 10 sq. n.m.) and decreased to 2 north of Olifants River.

The highest average number of catches per season (3) occurred in winter (see Table 7) with nil in autumn and one in spring and summer. As so few catch records were obtained in the Northern area over the comparatively long period of six years, it is considered that this *area is unimportant in relation to pilchard fishing.*

The vast majority of commercial catches during the period 1950-55 *viz. ninety-two per cent* (743) *of all catches, were made in the St. Helena Bay Area* (see Table 6).

Within this area average catch densities for the whole period were low in the north and increased steadily towards the south to a maximum density in the sub-area of Shell Bay Point. The catch density at the Donkin Bay sub-area (3) increased to 5 at Lambert's Bay, 7 at Cape Deseada and Klein Tafelberg and became 12 at Shell Bay Point. The density declined sharply farther south to 2 at Cape Columbine. This showed that *the area between Cape Deseada and Shell Bay Point was the area most intensively fished for pilchards.*

The analysis of catch densities on a seasonal basis for the St. Helena Bay Area (see Table 8) showed that *fishing intensity was highest in autumn and winter, declined rapidly in spring and was lowest in summer.*

During *autumn* catch densities were low in the north at Donkin Bay (1), increased at Lambert's Bay (5) and Cape Deseada (4) fell sharply at Klein Tafelberg (1), were highest at Shell Bay Point (22) and fell at Cape Columbine (1). This showed a very marked concentration of fish in the south.

In *winter* catch densities were low at Donkin Bay (1) in the north, increased at Lambert's Bay (4) and Cape Deseada (10), fell slightly at Klein Tafelberg (9), were highest at Shell Bay Point (12) and fell at Cape Columbine (1). This showed that pilchards were more evenly distributed between Shell Bay Point and Cape Deseada.

During *spring* catch densities were generally much lower and were reduced to nil in the northern sub-areas of Donkin Bay and Lambert's Bay. They were low at Cape Deseada (3) but rose to a maximum (8) at Klein Tafelberg and fell again at Shell Bay Point (5). This showed a tendency for slight northerly dispersal and even distribution like that seen in winter.

During *summer* catch densities were lowest and a general absence of pilchards in the area was evident. Catch densities varied between 0 and 2 and catches were made between Lambert's Bay and Shell Bay Point.

Four per cent (35) of the total number of commercial catches for the period 1950-1955 occurred in the *Southern Area* (see Table 9).

Within this area the average catch densities were low at the Cape Columbine sub-area (1) slightly higher at Saldanha Bay (2) and Dassen Island (2) and low at Robben Island (1) in the south (see Table 9).

The highest average number of catches per season (3) occurred in winter followed by autumn (2) and spring (1) (see Table 10). Only 2 catches in all were recorded during the summer (1953-54, see Table 9).

Catch densities during this period in the Southern Area showed that pilchards may be present in all seasons between Cape Columbine and Robben Island but that considerable variation may take place from year to year i.e. they may be present in one year and absent the next.

In order to find out whether any definite migration north or south along the coast was shown, an analysis of the data contained in Tables 7, 8 and 10 was carried out. The mean catch densities for each sub-area were arranged in the order Northern St. Helena Bay and Southern Areas (see below).

Season.	N. Olifants River.	Olifants River.	N. Donkin Bay.	S. Donkin Bay.	Lamberts Bay.	Deseada (Cape).	Tafelberg (Klein).	Shell Bay Point.	N. Columbine.	S. Columbine.	Saldanha.	Dassen.	Robben.
Summer	0	0	0	0	1	2	1	2	0	0	0	0	0
	—	0	0	0·3	1	1·3	1·7	1	0·7	0	0	0	—
Autumn	0	0	0	1	5	4	1	22	1	1	0	0	0
	—	0	0·3	2	3·3	3·3	9	8	8	0·7	0·3	0	—
Winter	0	2	1	1	4	10	9	12	1	0	1	1	1
	—	1	1·3	2	5	7·7	10·3	7·3	4·3	0·7	0·7	1	—
Spring	1	0	0	0	0	3	8	5	0	1	0	0	0
	—	0·3	0	0	1	3·7	5·3	4·3	2·0	0·3	0·3	0	—

These density figures were then smoothed by threes and the modes found.

From this it is seen that no significant seasonal north or south movement along the coast takes place.

(b) Discussion.

The plotting of the positions of the commercial catches of pilchards on a seasonal and monthly basis over a period of six years and the detailed analysis of catch positions and densities in relation to movement on and offshore and north and south has given results which may be expressed in the following general terms:—

Pilchards are present in greatest abundance in the commercial fishing areas in autumn and winter. Numbers decline in spring and are lowest in summer.

During December pilchards are rare or absent from these areas but during the remainder of the season are present. In late

January or early February the shoals appear and are caught inshore and offshore in the St. Helena Bay area. During February pilchards appear offshore and in March are farthest offshore. During the remainder of autumn and through winter up to the end of July the shoals are caught inshore in increasing numbers and in the southern region in the vicinity of Shell Bay Point in the St. Helena Bay area. In August pilchards caught offshore indicate the start of the offshore migration.

While inshore catches remain high through the spring months, catches increase progressively in the offshore areas showing a definite offshore migration consisting of successive shoals of fish and not the mass movement of the majority of pilchards. By November offshore catches reach a maximum and by December the shoals have largely disappeared from the area.

4. THE MOVEMENT OF PILCHARDS.

(a) In Relation to Feeding.

Investigations into the feeding of the pilchard over a period of more than six years (results as yet unpublished) have resulted in a considerable accumulation of data. As these data have not yet been analysed it is not possible to make any statement other than that the food of the pilchard off the West coast consists of both zooplankton and phytoplankton. It is interesting to note, however, that pilchards kept in an aquarium for tagging experiments lived entirely as particulate feeders for a period of six months.

In order to find out whether the presence of pilchards bears any relation to the abundance of plankton in St. Helena Bay a comparison was made between the mean seasonal commercial catches of pilchards for the period 1951 to 1955 (see Table 11 and Plate 11, figs. 1 and 2), and the mean seasonal settled volumes of plankton obtained by plankton tow-nettings during the period 1952-55 (see Table 12) and the mean seasonal abundance of phytoplankton for the years 1954 (de Jager, 1956) and 1955 (see Table 13), shown as units of abundance based on diatom counts at stations DA and DB (see Plate 12).

From the graphs (see Plate 12) it is seen that considerable fluctuations of phytoplankton may occur within a season. It is therefore necessary to consider the variations of the commercial catches of pilchards and their relationship with settled volumes of plankton and the abundance of phytoplankton on a monthly basis.

During the first half of summer, i.e. December and early January, pilchard shoals are not usually present in the St. Helena Bay area in large numbers. In late January or early February, however, they usually make their appearance and by the end of February in a normal year the numbers of catches are increasing rapidly.

In February plankton (including all the species found in pilchard stomachs) volumes are high but phytoplankton abundance is low.

During March commercial catches rise rapidly, settled volumes of plankton are at their highest and phytoplankton abundance has increased to an autumn maximum. In April commercial catches reach their maximum, plankton volumes decrease but remain high and phytoplankton decreases rapidly. In May, the end of autumn, catches of pilchards begin to decrease, volumes continue to decrease and phytoplankton abundance continues to decline.

During June and July pilchard catches are fairly high and remain steady, volumes continue to decrease and phytoplankton declines to a minimum. In August catches fall off rapidly, volumes reach a minimum but are nevertheless not very low and phytoplankton shows a slight increase.

In September catches continue to fall, plankton volumes increase and phytoplankton abundance suddenly reaches a high spring maximum. In October an increase in catches occurs together with an increase in volumes and a slight decrease in phytoplankton. In November the commercial catches decrease, plankton volumes remain steady while phytoplankton increases slightly in abundance.

It is seen therefore that the relationship between the abundance of pilchards in the St. Helena Bay area as shown by the amounts caught in the commercial catches, and the abundance of plankton in general and phytoplankton in particular is by no means simple.

It appears that there may be some relationship between the abundance of pilchards and settled volumes of plankton. A scatter diagram shows that some correlation exists in the period February to November (N.B. pilchards to a large extent absent before February) and it may be stated that during the times when pilchards are abundant plankton volumes remain fairly high but undergo a continuous decline.

The relationship between the abundance of pilchards and phytoplankton shows a similar decline.

It appears that during the period March to August when pilchards are most abundant in the St. Helena Bay area plankton abundance undergoes a steady decline. This is almost certainly due to the feeding of the pilchards coupled with the fact that less nutrients are available due to decreased upwelling. Tremendous numbers of pilchards actively feeding in a limited area must consume vast quantities of plankton.

In order to find out whether the feeding activities of the pilchards in the St. Helena Bay area had a direct effect on the condition of the fish, the mean monthly condition factor for male and female fish combined for the period 1950-54 was calculated and plotted (see Plate 12).

It appears that the condition factor varies in roughly the same manner as the abundance of plankton but that the extensive feeding of the pilchard shoals from March through to July does not have any " conditioning " effect.

(b) In Relation to Spawning.

For the years 1950 to 1955 all the positions where pilchard ova were obtained, other than those in St. Helena Bay or its immediate vicinity, were plotted. The reasons for the omission of St. Helena Bay were that the presence of pilchards is normally indicated by their appearance in the commercial catches and because in this area only incidental spawning takes place. Only ova in early stages of development were considered as they could be regarded as an indication that adult pilchards had recently been in the area.

During the course of the research programme pilchard ova were collected in three areas apart from St. Helena Bay in plankton tow-nettings made by R.S. *Africana II*. The first area was the routine research area covered by the Stations A-X and situated broadly between Robben Island and Lambert's Bay and extending up to 100 miles seawards (see Plate 13). Certain of the routine stations are near St. Helena Bay, these (L, M, N, O, P, Q) were discounted for this purpose. All these stations were occupied at least once a month throughout the period.

The second area was also situated off the West coast but extended roughly between Cape Town and Orange River and 100 miles seawards with the St. Helena Bay area excluded (see Plate 14). These stations were occupied every month for a period of over a year.

The third area covered the South coast region roughly between Slangkop and Cape Barracouta and extending southwards to a point approximately 60 miles offshore (see Plate 15). These stations were occupied whenever the opportunity occurred but were discontinued when they had been worked during each of the twelve months of a year.

The positions where pilchard ova were obtained other than in the area of St. Helena Bay were recorded (see Plates 13–17 and Table 14).

According to ova records off the West and South coasts the seasonal distribution of pilchard shoals was as follows:—

During *autumn* pilchards were present in the area off Saldanha Bay.

In *winter* pilchards were distributed from north of Robben Island (station U) to station B off St. Helena Bay on the West coast (see Plates 13 and 16).

During *spring* pilchards were present in the offshore area between stations U and C off the West coast (see Plate 13), and off the South coast between False Bay (station 2469, and eastwards almost to Quoin Point (station 2455), (see Plate 15).

In the *summer* ova records showed pilchards to be present off the West coast from south and west of Dassen Island (station V) to station D and almost as far north as Orange river [station X (66), see Plate 14]. On the South coast the distribution of pilchards extended from south of Cape Point (station 2528) along the South coast almost to Cape Barracouta (station 2518).

From these records of ova, it is evident that *pilchard shoals may at times be spread over very wide areas, particularly during the spring and summer months when main spawning occurs*, for example, the ova records between Orange River mouth on the West coast and Cape Barracouta on the South coast—a distance of nearly 500 miles. The record near Orange River mouth was an isolated one, however, and *it seems likely that pilchards move southwards and offshore from St. Helena Bay as far as False Bay, beyond which the direction of movement runs parallel with the coast.*

(c) In Relation to Environmental Factors.

In order to find out whether *sea temperature* has any relationship with the movements of pilchards, a comparison was made between the mean monthly commercial catches of pilchards in St. Helena Bay during the period 1951–55 and the monthly mean integral temperatures for the 0–50 metres layer in St. Helena Bay for the period 1951-54 (see Table 15).

An examination of the graph (see Plate 18) and construction of a scatter diagram showed that *there was no apparent relationship between the presence of pilchards in St. Helena Bay and water temperature as indicated by the mean integral values of the 0–50 metres layer.*

The variations in the monthly mean temperatures during the period were small and the lack of correlation is not surprising. It is nevertheless possible that changes in temperature of greater magnitude which might occur from time to time would have a considerable effect on the local movement of pilchard shoals.

It is well known that *wind* is an important factor in relation to the movements of fishes in general. The South African Weather Bureau has provided wind data based on hourly observations taken daily between 0830 and 1500 hours at Cape Columbine lighthouse situated just south of St. Helena Bay (see Plate 13). These data were taken over a period of ten years and give a very good indication of the prevailing winds and their seasonal variation in direction in the St. Helena Bay area (see Table 16).

In order to give an indication of the relative velocities of the various winds, a wind rose showing the mean percentage wind velocity per year averaged over the same period at Cape Columbine has been included (see Plate 20). This shows clearly that both the highest frequency and the highest velocities were recorded for winds from the south.

The commercial catches of pilchards for the five year period 1951-55 were averaged for each month and plotted graphically against the following:—

(1) The percentage frequency for all southerly (i.e. SE, S and SW) winds per month.

(2) The percentage frequency for SE and E winds per month.

(3) The percentage frequency for all northerly (i.e. NE, N and NW) winds per month.

(For graph see Plate 19.)

It appears that, in general, *the commercial catches vary inversely with the occurrence of southerly winds.* In the summer when the incidence of southerly winds is highest, pilchard catches are at their lowest. In the autumn when commercial catches increase rapidly, southerly winds undergo a steady decline. During winter commercial catches decline but remain high while southerly winds are at their lowest. In August, however, when commercial catches fall off, southerly winds increase rapidly. In the spring months catches are generally low but a rise occurs in October; southerly winds increase steadily.

The south-east and south winds were treated separately because of their more direct association with the phenomenon of upwelling, but showed the same trend as the graph for all southerly winds.

Northerly winds show a direct relationship with the commercial catches of pilchards. There is a low incidence of northerlies during the summer months of December and January when commercial catches are lowest. Northerly winds increase in February, March and April together with commercial catches. In May northerly winds are still increasing but catches have begun to decrease although both winds and catches remain high. In June and July northerlies are high and increasing in frequency and commercial catches fluctuate in a similar manner. Both fall in August and September. In October commercial catches increase while northerly winds remain the same as for September while in November the incidence of northerly winds decreases with a fall in commercial catches.

(d) Discussion.

An important factor in the movement of pilchards and their presence in St. Helena Bay is that at the time of their greatest abundance in the area, edible plankton is present in largest concentrations and adequate food supplies are available.

A very wide dispersal of pilchards away from the area of St. Helena Bay occurs mainly in spring and summer and is related to spawning. Indications of the presence of pilchard shoals from the evidence of recently spawned ova have shown them to be present as far north as Orange River on the West coast and as far east as Cape Barracouta on the South coast. The main tendency appears to be for pilchards to move south and west from St. Helena Bay in the spawning season, but to maintain contact with the coast, i.e. within 50-100 miles offshore.

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Although water temperatures are of great importance in the spawning of the pilchard (Davies, 1955), no apparent relationship between the presence of pilchards in the St. Helena Bay area and sea temperatures has so far been found.

On the other hand, however, the abundance of pilchards in the area bears a definite relationship to wind direction. In summer when the wind is strong and mainly from the south, the commercial catches are low. In autumn, as wind velocities decrease and winds become northerly, the commercial catches increase. In winter when wind velocities are generally low and winds come mainly from the north, commercial catches are high. In spring when southerly winds increase and northerly winds decrease, commercial catches show an increase and then decline.

In comparing wind direction with the seasonal positions of commercial catches of pilchards (see Plate 8) it is important to note that there is a definite relationship between southerly wind and the movement of pilchard shoals in relation to the shore. During summer when southerly wind frequency is highest pilchard shoals are generally offshore. Similarly in early autumn, when the incidence of southerly winds is still high, pilchard shoals are concentrated offshore. In late autumn and winter, however, when the least southerly wind is experienced, pilchard shoals are concentrated close inshore, where they remain through early spring, after which dispersal of shoals occurs associated with the increase in southerly winds.

In order to present these relationships in a form which may be of use to the commercial fishermen, the following simplified table has been prepared:—

TABLE 17.

THE GENERAL RELATIONSHIP BETWEEN THE PILCHARD FISHERY OF ST. HELENA BAY AND WIND.

	Summer. (Dec., Jan., Feb.)	Autumn (March, April, May.)	Winter. (June, July, August.)	Spring. (Sept., Oct., Nov.)
Pilchard catches.....	Lowest.....	Low, increasing to highest	High.....	High, declining to low.
Positions of catches...	Offshore (scattered)..	Offshore.....	Close inshore	Close inshore, then offshore (late in season).
Southerly wind.....	Highest.....	High, declining to low	Lowest.....	Low, increasing to high.
Northerly wind.....	Lowest.....	Low, increasing.....	High.....	Decreasing, to low.

The explanation of the relationships between the movements of pilchards and wind is probably by no means simple and at this stage cannot be attempted. When more detailed information on winds and their effect on water movements, temperatures, upwelling, nutrient content, etc. becomes available some explanation may be possible.

5. THE MOVEMENT OF PILCHARDS AS INDICATED BY PREDATORY FISH.

Pilchards are eaten by large predatory fish and porpoises at every opportunity, and by the examination of the stomachs of these predators records of pilchards in positions away from the commercial fishing areas were obtained.

Although the pilchard is eaten by many species of fish, its main predators are the Snoek, *Thyrsites atun* (Euphrasen) and Stockfish, *Merluccius capensis* Castlenau off the West coast, the Tunny, *Thynnus thynnus* (Linnaeus) (and other species) and Geelbek *Atractoscion aequidens* (Cuvier) off the South coast and the Spanish Mackerel *Scomberomorus commerson* (Lacepede) off the East coast.

Records of pilchards in snoek stomachs in the St. Helena Bay—Saldanha Bay area during the months of February and March are numerous and merely indicate the fact that when snoek pass through this area on their migration southwards they prey heavily on pilchards. Valuable records of pilchards from snoek stomachs have, however, been obtained in other areas.

During April pilchards were found in the stomachs of snoek caught off the West coast roughly 60 miles south of Luderitz (see Fig. 1). Details of these records are as follows:—

Date.	Position.	Catch.
(1) 14/4/55..	27° 33·4′ S. 15° 22·7′ E.	Two snoek containing a total of 3 pilchards.
(2) 14/4/55..	27° 47·8′ S. 15° 30·1′ E.	Two snoek containing a total of 4 pilchards.
(3) 15/4/55..	28° 56·6′ S. 16° 31·8′ E.	One snoek containing 1 pilchard.

During June large numbers of pilchards were obtained from snoek caught 3 miles off Duiker Point (see Plate 1). The record is as follows:—

11th June, 1952. Position approximately 3 miles west of Duiker Point, 54 snoek containing a total of 109 pilchards.

Records of pilchards in the stomachs of stockfish are numerous but are mainly confined to trawler catches made in the vicinity of Cape Columbine and Dassen Island at times when pilchard shoals are present in large numbers in these areas. A few instances have been recorded where pilchards have been found in stockfish stomachs on the trawling grounds off the West coast (centred approximately 45 miles northwest of Cape Town) during the summer months, showing that there may be a definite movement of pilchards offshore at this time of the year.

Although pilchards are said to appear frequently in the stomachs of tunny caught in the Cape Point* area (see Plate 1) authentic identifications of *Sardinops ocellata* are rare and up to now are confined to the months of December and January. Every attempt is being made to induce anglers to submit stomach contents in a good state of preservation for examination.

Large numbers of adult pilchards were recorded from the stomachs of geelbek caught near Cape Hangklip (see Plate 15) and landed at Hermanus during April, 1955. This shows that pilchards may be widely dispersed even during the period when the greatest concentrations are present in St. Helena Bay.

During June of each year large numbers of Spanish mackerel accompany the pilchard shoals which migrate up the Natal coast to Durban (see Fig. 1), and feed voraciously on the pilchards especially if they are close inshore. These records do not, however, provide any new information as the presence of the pilchard shoals is usually obvious due to their close proximity to the shore, when they are caught in large numbers and frequently become stranded.

Pilchards were thought to be present off the Natal coast only for a short time during the month of June each year. A new and important record of juvenile pilchards taken from the stomachs of Elf (Shad) *Pomatomus saltator* (Linnaeus) caught in a seine net on Durban beach on 3/11/55 has shown that juvenile pilchards of (standard) length 5·3–9·5 cm were present off the Natal coast. This is the first recording of juvenile pilchards off the Natal coast and is the first occasion that pilchards have been proved to be present in the area at a time other than during the "sardine run" in June.

From their presence in the stomachs of predatory fish, therefore, pilchards have been recorded off the West coast 60 miles south of Luderitz in April, and off Duiker Point in June, in False Bay in December and January, off Cape Hangklip in April and off Natal in June and November (juveniles).

6. THE MOVEMENT OF PILCHARDS AS INDICATED BY PREDATORY BIRDS.

Some reference to the location of pilchards by means of the shooting of predatory sea-birds has already been made (Davies, 1956). There is no doubt that this method is extremely useful as it enables shoals of unidentified fish to be sampled and identified without the use of nets and other gear which are frequently not efficient for the capture of juvenile fish.

Unfortunately, however, the shooting of predatory sea-birds has been confined mainly to the St. Helena-Saldanha Bay area where regular records of pilchards are normally provided from the sampling of commercial catches. The only record of pilchards away from this area was during March, 1954, when large pilchards were obtained from the stomach of a Gannet (*Morus capensis*) shot in the vicinity of Robben Island.

It is hoped that a special voyage may be undertaken from Cape Town to Durban to shoot predatory sea-birds at every opportunity for purposes of stomach content examination with a view to locating migratory pilchard shoals.

* Marked *Kaap die Goeie Hoop* on chart.

7. THE RELATIONSHIP BETWEEN THE COMMERCIAL CATCHES OF PILCHARDS MADE IN DIFFERENT AREAS.

(a) As shown by Vertebral Counts.

For the period March, 1950, to February, 1953, ten fish (5 males and 5 females) were taken from each 50-fish sample obtained from the commercial catches at the shore stations of Lambert's Bay and Stompneus for examination in relation to the pilchard research programme. The vertebral columns of these 10 pilchards were exposed by means of a longitudinal cut along the whole length of the fish, and scraping of the vertebral column. A vertebral count was then made.

From March, 1953, the Lambert's Bay shore station was closed and the Stompneus station continued alone. During December, 1953, a number of fish was obtained from False Bay.

The mean monthly vertebral counts for male and female pilchards were calculated (see Table 18) and due to the extraordinarily small differences in these average figures no evidence of racial differences between the fish caught at Lambert's Bay, Stompneus and False Bay during this period was apparent.

According to recent advances in the racial studies of pelagic fish populations by means of vertebral counts, little significance can be attached to differences in the number of vertebrae as these may easily be caused by groups of larval and juvenile fish becoming separated and encountering different sets of conditions of temperature, etc., during early growth.

(b) As shown by Size Composition.

A detailed study of the size composition of the commercial catches of pilchards made in St. Helena Bay is at present in progress and will appear in a later report. It is nevertheless of considerable importance in relation to migration to make a general comparison of the sizes of pilchards in the commercial catches made in the areas of Walvis Bay (South West Africa), St. Helena Bay, False Bay and off the coast of Natal (see Fig. 1).

For purposes of this comparison length frequencies calculated from 50-fish samples taken from the commercial catches made at the following times were used:—

Walvis Bay, for the whole year 1954 (Matthews, 1955), no table available; St. Helena Bay, June, 1954 (see Table 20), June, 1955 (see Table 23); False Bay, December, 1953 (see Table 19), December, 1954 (see Table 22); Natal coast, June, 1954 (see Table 21), June, 1955 (see Table 24).

N.B.—Pilchards were caught commercially in the areas of False Bay and Natal only during the months of December and June, respectively.

No table of length frequencies of commercial catches for Walvis Bay was available, so the graphs were used alone.

The above length frequencies were expressed as percentages and plotted (male and female fish separate) on two graphs (see Plates 21 and 22).

From the first series of graphs (see Plate 21, figs, 1 and 2) it is apparent that for purposes of this comparison, there is no reason to treat male and female fish separately. The False Bay catches were included in this comparison because they were caught in the summer season of 1954.

It appears that the Natal pilchards form a group of far smaller size than those normally caught in either St. Helena Bay or Walvis Bay. The majority of the Natal pilchards are sexually immature fish (standard length at first maturity for males and females = 18–18·5 cm; 50 per cent of males mature at 18·5–20·0 cm; 50 per cent of females mature at 19·0–20·5 cm; 100 per cent males and females mature at 20·5–22 cm—Davies, 1956), if the size at sexual maturity for East coast pilchards is the same as that for West coast fish. There is some indication of there being two main size groups as shown by the peaks at 15–16 cm and 18–19 cm lengths.

While the Natal pilchards are almost entirely different from the Walvis Bay and St. Helena Bay fish on the basis of size composition, the False Bay pilchards show an extremely wide range of size and consist of fish of sizes represented in the Natal, Walvis Bay and St. Helena Bay catches. A large proportion of the False Bay pilchards are, however, also sexually immature.

The second series of graphs (see Plate 22, figs. 1 and 2) also show that it is unnecessary to treat males and females separately.

Again the Natal pilchards formed a group of wide length range similar to that obtained in the previous year. There was a pronounced peak at the lengths 16–18 cm and an indication that larger females of length 22–23 cm were present. The majority of the fish were sexually immature.

During 1955 the Natal pilchards were nearly all smaller than those caught in False Bay, St. Helena Bay and Walvis Bay. The size composition of the False Bay pilchards for December, 1954, was far more limited than in the previous year and coincided to a large extent with that of Walvis Bay.

(c) Discussion.

On the basis of size composition it appears that the Natal pilchards form a group quite separate from those caught in St. Helena Bay and Walvis Bay. The False Bay pilchards may consist of fish of very wide length range and may therefore be connected with both the Natal fish or the West coast pilchards of Walvis Bay. False Bay is situated geographically between the two areas.

It appears, therefore, that the smaller and generally sexually immature pilchards are confined to the South and East coasts and to some extent to the S.W. African coast while the larger and generally sexually mature fish are confined to the West coast region of St. Helena Bay.

8. MIGRATION.

In this section various ideas concerning the migration of the South African pilchard are discussed, but until more definite information from tagging returns becomes available, all that follows should be regarded as hypothetical.

St. Helena Bay and its immediate surroundings may be regarded as the main feeding grounds for the pilchard in Union waters, and Walvis Bay the main feeding area for pilchards off South West Africa, due to the high productivity and abundance of edible plankton associated with the sheltered nature of these two areas. Although the whole of the West coast region is one of high productivity due to upwelling, it seems evident that pilchards require sheltered conditions and for this reason they become concentrated in areas such as Baia dos Tigres, Walvis Bay and the St. Helena Bay area. Some portion of the S.W. African pilchard population is sexually mature and spawning is known to take place there. On the other hand the majority of the St. Helena Bay pilchards are sexually mature and move southwards and to deeper waters to spawn.

Walvis Bay and St. Helena Bay may therefore be regarded as areas (see Plate 23, fig. 1) in which pilchards remain for purposes of feeding prior to their departure to warmer, less productive areas for purposes of spawning.

The population of pilchards caught in Walvis Bay consists of smaller fish than those caught in St. Helena Bay (Davies, 1956). Of these fish, the proportion which has become sexually mature probably moves offshore to deeper, warmer water for spawning. It is possible that the spawning which takes place in S.W. African waters may provide the commercial population of pilchards fished by Angola in the Baia dos Tigres.

It is considered probable that when the S.W. African fish reach sexual maturity, they migrate south and join the St. Helena Bay population. Tagging has shown that snoek, one of the most important predators of the pilchard, migrate south to the Cape (Davies, 1954), and pilchards have been recorded in the stomachs of snoek to the south of Luderitz (see section 5). It is possible that the snoek migration takes place each year at the same time as the migration of pilchards from Walvis Bay to St. Helena Bay.

The mature pilchards of St. Helena Bay, having fed extensively during the autumn and winter months, migrate to the south and offshore but remain within a limited distance (probably under 100 miles) of the shore, for purposes of spawning. This migration may continue from late winter through to the middle of summer. The departure of the pilchard shoals from St. Helena Bay is, however, not concerted and a succession of departures of individual shoals through the spring months takes place.

Spawning takes place in an extended area between St. Helena Bay and Cape Barracouta but is most concentrated between Saldanha Bay and Cape Town (Davies, 1956). According to the *Africa Pilot* (British Admiralty, Part II, 1939), the Benguela current flows northwards up the West coast of Africa towards the equator. From this it might be assumed that pilchard ova spawned in the area between Cape Town and Dassen Island would be carried northwards with the Benguela current. This may be generally true, but according to the results of recent investigations in the area between Cape Point and Orange River mouth, carried out in relation to the Pilchard Research Programme, a considerable amount of variation of the recognised main northerly movement may take place in the inshore area (Clowes, 1954). This variation consists of surface currents moving in almost any direction including to the south against the main Benguela current.

The effect of these currents is to delay the transport to the north of pilchard ova and larvae. The extent of the delay is not known but may be considerable and could conceivably retain the ova in the area until they had hatched, and the larvae until they had become juveniles. In general, therefore, it is likely that large numbers, and perhaps the majority of pilchard ova hatch, develop and become juveniles without being carried very far away from the area in which original spawning took place.

Off the South coast between Cape Point and Cape Barracouta, where a certain amount of spawning of pilchards takes place, drift card experiments have shown that a similar effect to that described above occurs due to surface currents which run in all directions including counter to that of the main Agulhas current. This would tend to retain the ova and larvae of pilchards until they had undergone final metamorphosis into juveniles and had become capable of independent locomotion.

Having considered the three areas, viz. Walvis Bay—a feeding area for young and adult fish, St. Helena Bay—a feeding area for adult fish, and the area between Saldanha Bay and Cape Barracouta—the main spawning grounds of the pilchard in Union waters, there remain the nursery grounds of the juvenile pilchards and the anomalous " sardine run " of the Natal coast.

Extensive sampling of shoals of young fish by means of dynamite, small mesh seine nets, the shooting of seabirds and examination of stomach contents, and recently by means of the blanket net, has shown that juvenile pilchards occur in large shoals in St. Helena Bay, Saldanha Bay, Table Bay and False Bay, and close inshore between these bays. Their movements are sporadic and large numbers of shoals of juvenile pilchards may be recorded in an area one day but be entirely absent from that area a short time later. Largest numbers are found in the above areas during the summer and autumn. Juveniles have also been recorded at Walvis Bay, and more recently off Durban.

It is of interest to record the movements of the California sardine as summarised by Clark (1940), who writes:—

> " Most of the adults collect to spawn in southern California waters from March to June. The young fish remain on the nursery grounds in southern California and northern Lower California for perhaps six months or a year. In their second summer, if not earlier, they exhibit some northward movement and the extent of this northward movement increases year by year. The largest and oldest fish reach the waters of British Columbia, Washington and Oregon. This summer northward migration is followed by a southward return in the fall and winter preparatory to the spring spawning."

It appears that the areas between Lambert's Bay and False Bay are the main nursery grounds for juvenile pilchards (see Plate 23, fig. 2) and that like the California sardine juveniles they tend to move northwards as they increase in size. This seems likely because the largest concentrations of medium to large-sized pilchards are found to the north of Cape Point on both the West and East coasts. If juvenile pilchards tend to move northwards at some stage in their growth, then those shoals which were to the east of Cape Point would probably move along the South coast to the East coast and finally northwards along the Natal coast. Those shoals which were to the west of Cape Point would probably carry out their northerly migration up the West coast. In this manner juveniles moving up the West coast would eventually reach Walvis Bay.

Off the West coast records of juvenile pilchards are frequent in the area from Cape Point to Lambert's Bay and fairly common at Walvis Bay, but no data in relation to the presence of juvenile pilchards on the South and East coasts are available apart from the single record of juveniles at Durban in November, 1955. Records of " sardines " along the coast between Cape Agulhas and Natal are, however, very numerous but authentic indentifications of *Sardinops ocellata* juveniles are entirely lacking. It is likely that juvenile pilchards are to be found close inshore from Cape Point to Durban.

If juvenile pilchards do migrate northwards up the East coast it is difficult to see the connection between them and the " sardine run " which consists of larger fish.

The " sardine run " consists of large numbers of extensive shoals of pilchards which move northwards up the coast from Port St. Johns to Durban every year. These shoals move up the coast close to the shore and when they reach Durban they disappear. They have never been recorded north of Durban and it is thought that they turn out to sea perhaps to return to the Cape with the aid of the Agulhas current.

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Table 1.

Seasonal Variation in the Positions of Commercial Catches, 1950–55.

Year.	Autumn.	Winter.	Spring.	Summer.	
1950.	Catches mainly offshore, in an extended line N. and S., and concentrated N. of Stompneus.	Catches close inshore from Lamberts Bay southwards. Catches in the S. rather scattered N. of Stompneus.	Catches mainly close inshore; scattered in St. Helena Bay.	Few scattered catches offshore in St. Helena Bay.	Lambert's Bay and Stompneus.
1951.	Catches mainly offshore except off Lamberts Bay and Stompneus (inshore), in an extended line N. and S. and concentrated N. of Stompneus.	Catches mainly close inshore but scattered in the S. of St. Helena Bay.	Catches mainly close inshore but inclined to be patchy.	Few scattered catches in St. Helena Bay.	
1952.	Catches mainly offshore and concentrated off Lamberts Bay and Stompneus.	Catches close inshore, scattered in the S. of St. Helena Bay but more concentrated to the N. of Stompneus.	Catches mainly inshore; scattered in St. Helena Bay.	Catches scattered, mainly offshore between Lamberts Bay and Stompneus.	
1953.	Catches mainly offshore and concentrated N. of Stompneus.	Catches mainly concentrated to the N. of Stompneus.	Few scattered catches only in St. Helena Bay; catches made to the S. vicinity Saldanha Bay.	Few scattered catches offshore.	Stompneus only.
1954.	Catches mainly offshore and concentrated N. of Stompneus. Catches early in the season N. of Robben Island.	Catches generally inshore but scattered to the N. of Stompneus.	Catches inshore in St. Helena Bay; offshore and to the S. later in the season.	Few scattered catches offshore and to the S. late in season.	
1955.	Catches offshore and widely scattered throughout St. Helena Bay.	Catches close inshore, patchy and extending far N. Scattered to the N. of Stompneus.	Catches in a line W. to E. in St. Helena Bay; to the S. later in the season.	Few scattered catches to the N. in February only.	

TABLE 2.

MEAN MONTHLY DISTANCES OFFSHORE OF COMMERCIAL CATCHES OF PILCHARDS, 1953–55.

Distance Offshore.	Year.	Numbers of Catches.											
		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Nautical miles— 0–5 (Zone 1)...	1953.....	(2) 1	(12) 3	(12) 2	(5) 1	(12) 2	(10) 3	(9) 3	(6) 2	(7) 3	(2) 2	(2) 2	—
	1954.....	(5) 2	(2) 0	(3) 1	(8) 1	(17) 9	(11) 5	(12) 6	(1) 1	(5) 5	(1) —	(3) —	—
	1955.....	—	(8) 2	(30) —	(5) 1	(10) —	(18) 15	(8) 8	(13) 5	(22) 9	(1) —	(1) 1	—
	Mean Percent...	43	23	7	17	28	59	59	40	50	50	50	—
0–10 (Zone 2)..	1953.....	—	12	12	3	12	10	9	5	7	2	2	—
	1954.....	5	0	3	7	15	10	12	1	5	1	—	—
	1955.....	—	5	11	3	7	17	8	12	22	0	1	—
	Mean Percent...	71	77	58	72	87	95	100	90	100	75	50	—
0–20 (Zone 3)...	1953.....	1	12	12	5	12	10	9	5	7	2	2	—
	1954.....	5	2	3	8	17	11	12	1	5	1	3	—
	1955.....	—	8	24	5	10	18	8	13	22	1	1	—
	Mean Percent...	100	100	87	100	100	100	100	95	100	100	100	—
Over 20 (Zone 4)	1953.....	—	—	—	—	—	—	—	1	—	—	—	—
	1954.....	—	—	—	—	—	—	—	—	—	—	—	—
	1955.....	—	—	6	—	—	—	—	—	—	—	—	—
	Mean Percent...	—	—	13	—	—	—	—	5	—	—	—	—

N.B.—Numbers in brackets indicate total numbers of catch positions per month.

894658—4

TABLE 3.

MEAN SEASONAL DISTANCES OFFSHORE OF COMMERCIAL CATCHES OF PILCHARDS, 1950–55.

Year.	Distance Offshore.	Zone No.	Autumn.	Winter.	Spring.	Summer.
			Percentage.	Percentage.	Percentage.	Percentage.
1950	0–5	1	30	85	76	50
	0–10	2	78 (50)	100 (75)	95 (42)	70 (10)
	0–20	3	100	100	5	100
	Over 20	4	0	0	0	0
1951	0–5	1	68	67	75	37
	0–10	2	94 (50)	69 (67)	93 (28)	89 (27)
	0–20	3	100	100	100	100
	Over 20	4	0	0	0	0
1952	0–5	1	15	48	55	27
	0–10	2	86 (72)	90 (69)	68 (22)	87 (15)
	0–20	3	97	100	100	100
	Over 20	4	1	0	0	0
1953	0–5	1	21	44	50	22
	0–10	2	93 (28)	97 (32)	86 (14)	56 (9)
	0–20	3	100	97	100	100
	Over 20	4	0	1	0	0
1954	0–5	1	34	68	56	25
	0–10	2	78 (32)	100 (25)	78 (9)	88 (8)
	0–20	3	100	100	100	100
	Over 20	4	0	0	0	0
1955	0–5	1	8	68	42	—
	0–10	2	53 (40)	98 (44)	96 (24)	—
	0–20	3	85	100	100	—
	Over 20	4	15*	0	—	—

N.B.—Numbers in brackets indicate total numbers of catch positions per season.
* Up to 31 miles offshore.

TABLE 4.

THE SEASONAL MEANS OF THE DISTANCES OFFSHORE OF THE COMMERCIAL CATCHES FOR THE YEARS 1950–55.

Distance Offshore.	Autumn.	Winter.	Spring.	Summer.
Nautical miles offshore—	Percentage.	Percentage.	Percentage.	Percentage.
0–5	29	63	59	32
0–10	80	92	86	78
0–20	97	99	100	100
Over 20 nautical miles from shore	3*	½	0	0

* Nil for 5 years. 15 per cent for 1955.

TABLE 5.

THE SEASONAL DISTRIBUTION OF COMMERCIAL CATCHES OF PILCHARDS IN THE NORTHERN AREA, 1950–55.

Year.	Season.	Total Number of Catches.	Catch Density.*		
			North of Olifants River.	Olifants River.	North of Donkin Bay.
1950	Autumn	—	—	—	—
	Winter	—	—	—	—
	Spring	3	3	—	—
1950–51	Summer	—	—	—	—
1951	Autumn	1	—	—	1
	Winter	1	—	—	1
	Spring	1	—	—	1
1951–52	Summer	2	2	—	—
1952	Autumn	2	—	2	—
	Winter	9	—	4	5
	Spring	2	—	2	—
1952–53	Summer	3	1	—	2
1953	Autumn	—	—	—	—
	Winter	—	—	—	—
	Spring	—	—	—	—
1953–54	Summer	—	—	—	—
1954	Autumn	—	—	—	—
	Winter	—	—	—	—
	Spring	—	—	—	—
1954–55	Summer	—	—	—	—
1955	Autumn	—	—	—	—
	Winter	8	—	7	1
	Spring	—	—	—	—
TOTAL		32	6	15	11
Mean density of catches			2*	4*	2*

* Expressed in numbers of commercial catches per 10 square miles.

TABLE 6.

THE SEASONAL DISTRIBUTION OF COMMERCIAL CATCHES OF PILCHARDS IN THE ST. HELENA BAY AREA, 1950–55.

Year.	Season.	Total No. of Catches.	Catch Density.*					
			S. of Donkin Bay.	Lamberts Bay.	Cape Deseada.	Klein Tafelberg.	Shell Bay Point.	N. of Cape Columbine.
1950.....	Autumn.....	50	—	3	7	2	26	1
	Winter.....	74	—	18	21	26	9	—
	Spring.....	39	—	1	11	15	8	—
1950–51.....	Summer.....	11	2	1	—	2	—	—
1951.....	Autumn.....	51	—	7	3	3	31	2
	Winter.....	65	—	3	18	16	11	1
	Spring.....	28	—	2	2	14	4	—
1951–52.....	Summer.....	25	—	4	3	—	6	—
1952.....	Autumn.....	69	4	19	—	—	31	—
	Winter.....	59	4	3	—	6	28	1
	Spring.....	21	—	—	3	5	2	—
1952–53.....	Summer.....	9	—	2	—	—	5	—
1953.....	Autumn.....	29	—	—	—	1	19	4
	Winter.....	27	—	—	2	—	11	—
	Spring.....	11	—	—	—	3	4	—
1953–54.....	Summer.....	7	—	—	1	2	1	—
1954.....	Autumn.....	26	—	—	4	—	19	—
	Winter.....	24	—	—	3	4	10	—
	Spring.....	7	—	—	—	4	—	—
1954–55.....	Summer.....	8	—	1	5	—	—	—
1955.....	Autumn.....	48	—	2	9	1	3	—†
	Winter.....	31	2	1	15	—	5	3
	Spring.....	24	—	—	2	10	11	—
TOTAL.....		743	12	67	109	114	244	12
Mean density of catches.....			3*	5*	7*	7*	12*	2*

* Expressed in numbers of commercial catches per 10 square miles.

† Scattered catches in middle of St. Helena Bay area up to 14.

TABLE 7.

THE MEAN CATCH DENSITY PER SUB-AREA PER SEASON IN THE NORTHERN AREA, 1950–55.

Season.	Mean No. of Catches per Season.	Mean Catch Density*		
		North of Olifants River.	Olifants River.	Donkin Bay.
Autumn.....	0	0	0	0
Winter.....	3	0	2	1
Spring.....	1	1	0	0
Summer.....	1	0	0	0

* Calculated from Table 5 and expressed in numbers of commercial catches per 10 square miles.

TABLE 8.

THE MEAN CATCH DENSITY PER SUB-AREA PER SEASON IN THE ST. HELENA BAY AREA, 1950–55.

Season.	Mean No. of Catches per Season.	Mean Catch Density.*					
		Donkin Bay.	Lamberts Bay.	Cape Deseada.	Klein Tafelberg.	Shell Bay Point.	Cape Columbine.
Autumn	46	1	5	4	1	22	1
Winter	47	1	4	10	9	12	1
Spring	22	0	0	3	8	5	0
Summer	12	0	1	2	1	2	0

* Calculated from Table 6 and expressed in numbers of commercial catches per 10 square miles.

TABLE 9.

THE SEASONAL DISTRIBUTION OF COMMERCIAL CATCHES OF PILCHARDS IN THE SOUTHERN AREA, 1950–55.

Year.	Season.	Total No. of Catches.	Catch Density.*			
			S. of Cape Columbine.	Saldanha B.	Dassen I.	Robben I.
1950	Autumn	—	—	—	—	—
	Winter	—	—	—	—	—
	Spring	—	—	—	—	—
1950–51	Summer	—	—	—	—	—
1951	Autumn	2	1	1	—	—
	Winter	—	—	—	—	—
	Spring	—	—	—	—	—
1951–52	Summer	—	—	—	—	—
1952	Autumn	—	—	—	—	—
	Winter	—	—	—	—	—
	Spring	—	—	—	—	—
1952–53	Summer	—	—	—	—	—
1953	Autumn	—	—	—	—	—
	Winter	5	1	1	3	—
	Spring	3	1	2	—	—
1953–54	Summer	2	—	2	—	—
1954	Autumn	7	2	3	1	1
	Winter	4	—	3	1	1
	Spring	2	2	—	—	—
1954–55	Summer	—	—	—	—	—
1955	Autumn	—	—	—	—	—
	Winter	9	—	4	2	3
	Spring	1	—	—	—	1
	TOTAL	35	7	16	7	6
Mean density of catches			1*	2*	2*	1*

* Expressed in numbers of commercial catches per 10 square miles.

TABLE 10.

THE MEAN CATCH DENSITY PER SUB-AREA PER SEASON IN THE SOUTHERN AREA, 1950–55.

Season.	Mean No. of Catches per Season.	Mean Catch Density.*			
		Cape Columbine.	Saldanha Bay.	Dassen Island.	Robben Island.
Autumn	2	1	0	0	0
Winter	3	0	1	1	1
Spring	1	1	0	0	0
Summer	0	0	0	0	0

* Calculated from Table 9 and expressed in numbers of commercial catches per 10 square miles.

TABLE 11.

MEAN MONTHLY AND SEASONAL COMMERCIAL CATCHES OF PILCHARDS, 1951–55.

Period January, 1951—December, 1955.	Mean Monthly Catches.	Season.	Mean Seasonal Catches.
	tons.		tons.
December	979 (4)		
January	726 (5)	Summer	8,292
February	6,587 (5)		
March	20,277 (5)		
April	25,897 (5)	Autumn	67,026
May	20,852 (5)		
June	18,705 (5)		
July	18,833 (5)	Winter	47,091
August	9,553 (5)		
September	7,552 (3)		
October	13,832 (1)	Spring	30,912
November	9,528 (3)		

N.B.—Numbers in brackets indicate number of years from which means were obtained.

TABLE 12.

SEASONAL VARIATION OF PLANKTON IN THE ST. HELENA BAY AREA, 1952–1955.*

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	c.c.	c.c.	c.c.	c.c.	c.c.	c,c.	c.c.	c.c.	c.c.	c.c.	c.c.	c.c.
1952	6	14	8	22	30	32	8	11	14	6	22	53
1953	26	43	49	30	25	11	10	10	13	10	13	41
1954	62	51	50	24	7	18	4	3	9	24	10	24
1955	17	14	41	30	25	15	24	14	15	24	17	8
Mean	28	31	37	27	22	19	12	10	13	16	16	32

* Calculated from the mean settled volumes obtained from N70 vertical net, 100–0M, at Stations L, M, N, O, Q, (see Plate 13).

TABLE 13.

ABUNDANCE OF PHYTOPLANKTON IN THE ST. HELENA BAY AREA.*

Month.	Phytoplankton 1954–55—Units of Abundance.†
January	9,832,250
February	1,250,000
March	7,189,750
April	2,428,750
May	457,500
June	1,066,250
July	—
August	407,500
September	12,125,250
October	10,385,000
November	10,991,500
December	12,500,000

* Based on diatom counts at stations DA and DB (see Plate 13) for the years 1954 and 1955.

† Units of abundance based on the average *total* counts of phytoplankton cells for each station for the two years.

TABLE 14.

SELECTED POSTIONS WHERE PILCHARD OVA WERE RECORDED DURING THE PERIOD 1950–55. (SEE PLATES 13–17.)

Month.	Season.	Routine Stations.	South Coast Search Stations.	West Coast Search Stations.
March	Autumn.	G, T.	—	—
April		—	—	—
May		—	—	—
June	Winter.	U, V.	—	—
July		U, V, X, R, H, G.	—	—
August		X, W, R, H, G, S, A, B,	—	—
September	Spring.	U, V W, X, R, H, T, A, B.	2451, 2454, 2455, 2460, 2469, 2470, 2471, 2473, 2475.	—
October		U, X, R, H, T, B, C.	—	—
November		V, W, X, H, T, C.	—	—
December	Summer.	X, R, T, S, A, B, C, D.	2477, 2478, 2486, 2487, 2488, 2489, 2496, 2492, 2493.	X (66) *
January		R, H, G, S, A, B, C, D,	2512, 2513, 2515, 2517, 2518, 2519.	—
February		V, X, H, A, C.	2528.	—

* December, 1952—see plate 14.

TABLE 15.

MEAN INTEGRAL TEMPERATURES FOR 0–50 METRE LAYER FOR FOUR YEAR PERIOD, 1951–54.*

Month.	Mean Temperature. 0–50 m.
	°C.
January	11·36
February	10·98
March	11·50
April	12·05
May	12·25
June	12·09
July	12·51 (3 years only)
August	12·38
September	12·55
October	11·13
November	10·96
December	11·27

* Calculated from temperatures recorded at stations L, M, N, O and Q.

TABLE 16.

PERCENTAGE WIND FREQUENCIES FOR CAPE COLUMBINE.*

Month.	Northerly.	Southerly.	S.E. and S.	E.	W.	Calm.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
March	20	70	65	2	4	4
April	28	60	52	3	4	5
May	42	45	37	4	5	4
Autumn	30	58	51	3	4	4
June	44	42	35	5	6	3
July	45	38	32	6	7	4
August	38	46	38	4	7	5
Winter	42	42	35	5	7	4
September	25	61	52	3	6	4
October	25	62	56	3	7	3
November	14	77	67	1	6	2
Spring	21	67	58	2	6	3
December	13	81	72	1	4	1
January	11	84	78	0	3	2
February	13	81	75	1	2	3
Summer	12	82	75	1	3	2

* From data provided by the Weather Bureau, Pretoria, and based on hourly observations between 0830 and 1500 hours taken daily over the period 1939–48.

TABLE 18.

MEAN VERTEBRAL COUNTS OF PILCHARDS, 1950–54.

Month.	1950.				1951.				1952.				1953.				1954.	
	Stompneus.		Lamberts Bay.		Stompneus.		Lamberts Bay.		Stompneus.		Lamberts Bay.		Stompneus.		Lamberts Bay.		Stompneus.	
	Mean Vertebral Count.		Mean Vertebral Count.		Mean Vertebral Count.		Mean Vertebral Count.		Mean Vertebral Count.		Mean Vertebral Count.		Mean Vertebral Count.		Mean Vertebral Count.		Mean Vertebral Count.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
January.....	—	—	—	—	49·00	49·00	49·50	49·00	49·17	49·17	49·33	48·83	—	—	49·33	49·67	49·18	49·20
February...	—	—	—	—	49·33	49·33	49·17	49·50	49·28	49·17	49·27	49·33	49·20	49·18	49·28	49·28	49·75	49·20
March.....	49·64	49·81	—	—	49·00	49·06	49·33	49·08	49·08	49·17	49·25	49·08	49·17	49·08	—	—	49·00	49·00
April.....	49·83	49·96	49·33	49·00	49·00	49·07	49·33	49·15	49·24	49·20	49·22	49·19	49·33	49·15	—	—	49·37	49·33
May.....	49·91	49·96	49·25	49·42	49·07	49·13	49·37	49·21	49·14	49·10	49·17	49·13	49·19	49·33	—	—	49·10	49·24
June.....	49·81	49·91	49·27	49·20	49·21	49·06	49·53	49·20	49·14	49·19	49·08	49·17	49·08	49·25	—	—	49·33	49·24
July.....	49·85	49·93	49·29	49·31	49·15	49·10	49·39	49·39	49·18	49·32	49·45	49·21	49·00	49·10	—	—	49·29	49·19
August.....	49·80	49·71	49·22	49·37	49·11	49·14	49·50	49·35	49·15	49·21	49·28	49·17	49·07	49·29	—	—	49·00	49·17
September..	49·46	49·82	48·88	49·30	49·33	49·08	—	—	—	—	—	—	49·26	49·26	—	—	49·08	49·08
October....	49·20	49·60	49·41	49·17	—	—	49·50	48·66	49·00	49·00	—	—	49·50	49·20	—	—	49·30	49·48
November..	49·36	49·34	49·29	49·32	49·12	49·18	49·26	49·29	49·17	49·10	49·33	49·22	49·33	49·50	—	—	49·17	49·17
December...	49·88	49·57	49·00	49·50	49·22	49·00	49·00	49·33	—	—	—	—	—	—	—	—	—	—
Mean.....	49·67	49·76	49·22	49·29	49·14	49·10	49·35	49·20	49·16	49·16	49·26	49·15	49·21	49·23	49·30	49·47	49·23	49·21
															False Bay.			
															49·25	49·17		

Reprint from "Commerce & Industry", November, 1956

TABLE 19.

FALSE BAY PILCHARDS*, DECEMBER, 1953.

Length Group (1c.)	M.	Frequency.	F.	Frequency.
cm		%		%
14·0–14·4	1	1	—	—
14·5–14·9	2	2	5	4
15·0–15·4	9	7	7	5
15·5–15·9	13	11	14	11
16·0–16·4	6	5	13	10
16·5–16·9	11	9	4	3
17·0–17·4	9	7	7	5
17·5–17·9	8	7	5	4
18·0–18·4	14	11	11	9
18·5–18·9	6	5	10	8
19·0–19·4	5	4	16	11
19·5–19·9	2	2	1	1
20·0–20·4	3	2	4	3
20·5–20·9	2	2	2	1
21·0–21·4	12	11	5	4
21·5–21·9	6	5	9	8
22·0–22·4	9	7	7	6
22·5–22·9	1	1	5	4
23·0–23·4	—	—	—	—
23·5–23·9	—	—	1	1
TOTAL..	119		126	

* Samples taken from commercial catches.

TABLE 20.

ST. HELENA BAY PILCHARDS,* JUNE, 1954.

Length Group (1c.)	M.	Frequency.	F.	Frequency.
cm		%		%
20·0–20·4	2	1	2	1
20·5–20·9	6	3	10	3
21·0–21·4	24	11	15	5
21·5–21·9	57	26	36	11
22·0–22·4	61	28	67	20
22·5–22·9	40	18	84	25
23·0–23·4	20	9	60	18
23·5–23·9	8	4	39	12
24·0–24·4	1	0	13	4
24·5–24·9	—	—	—	—
25·0–25·4	—	—	4	1
25·5–25·9	—	—	1	0
TOTAL..	219		331	

* Samples taken from commercial catches.

TABLE 21.

NATAL PILCHARDS,* JUNE, 1954.

Length Group (1c.)	M.	Frequency.	F.	Frequency.
cm		%		%
14·5–14·9	—	—	2	4
15·0–15·4	7	10	2	4
15·5–15·9	7	10	8	15
16·0–16·4	9	13	4	7
16·5–16·9	3	4	6	11
17·0–17·4	6	8	1	2
17·5–17·9	7	10	2	4
18·0–18·4	7	10	4	7
18·5–18·9	7	10	11	20
19·0–19·4	7	10	9	16
19·5–19·9	7	10	5	9
20·0–20·4	2	3	1	2
TOTAL..	69		55	

* Samples taken from seine net catches.

TABLE 22.

FALSE BAY PILCHARDS,* DECEMBER, 1954.

Length Group (1c.)	M.	Frequency.	F.	Frequency.
cm		%		%
19·0–19·4	—	—	1	1
19·5–19·9	1	3	2	2
20·0–20·4	8	22	14	12
20·5–20·9	12	33	17	15
21·0–21·4	4	11	24	21
21·5–21·9	4	11	26	23
22·0–22·4	5	14	14	12
22·5–22·9	2	6	12	11
23·0–23·4	—	—	3	3
23·5–23·9	—	—	1	1
TOTAL..	36		114	

* Samples taken from commercial catches.

TABLE 23.

ST. HELENA BAY PILCHARDS*, JUNE, 1955.

Length Group (1c.)	M.	Frequency.	F.	Frequency.
cm		%		%
19·0–19·4	—	—	2	0
19·5–19·9	—	—	—	—
20·0–20·4	1	0	2	0
20·5–20·9	11	3	2	0
21·0–21·4	56	15	24	5
21·5–21·9	110	29	76	15
22·0–22·4	108	28	137	26
22·5–22·9	61	16	121	23
23·0–23·4	26	7	91	17
23·5–23·9	5	1	43	8
24·0–24·4	1	0	17	3
24·5–24·9	—	—	5	2
TOTAL..	379		520	

* Samples taken from commercial catches.

TABLE 24.

NATAL PILCHARDS,* JUNE, 1955.

Length Group (1c.)	M.	Frequency.	F.	Frequency.
cm		%		%
15·5–15·9	6	5	1	1
16·0–16·4	12	11	8	6
16·5–16·9	26	23	16	12
17·0–17·4	31	28	30	22
17·5–17·9	7	6	29	21
18·0–18·4	11	10	13	9
18·5–18·9	7	6	16	12
19·0–19·4	7	6	14	10
19·5–19·9	5	4	6	4
20·0–20·4	1	1	3	2
20·5–20·9	—	—	—	—
21·0–21·4	—	—	—	—
21·5–21·9	—	—	—	—
22·0–22·4	—	—	1	1
TOTAL..	113		137	

* Samples taken from seine net catches.

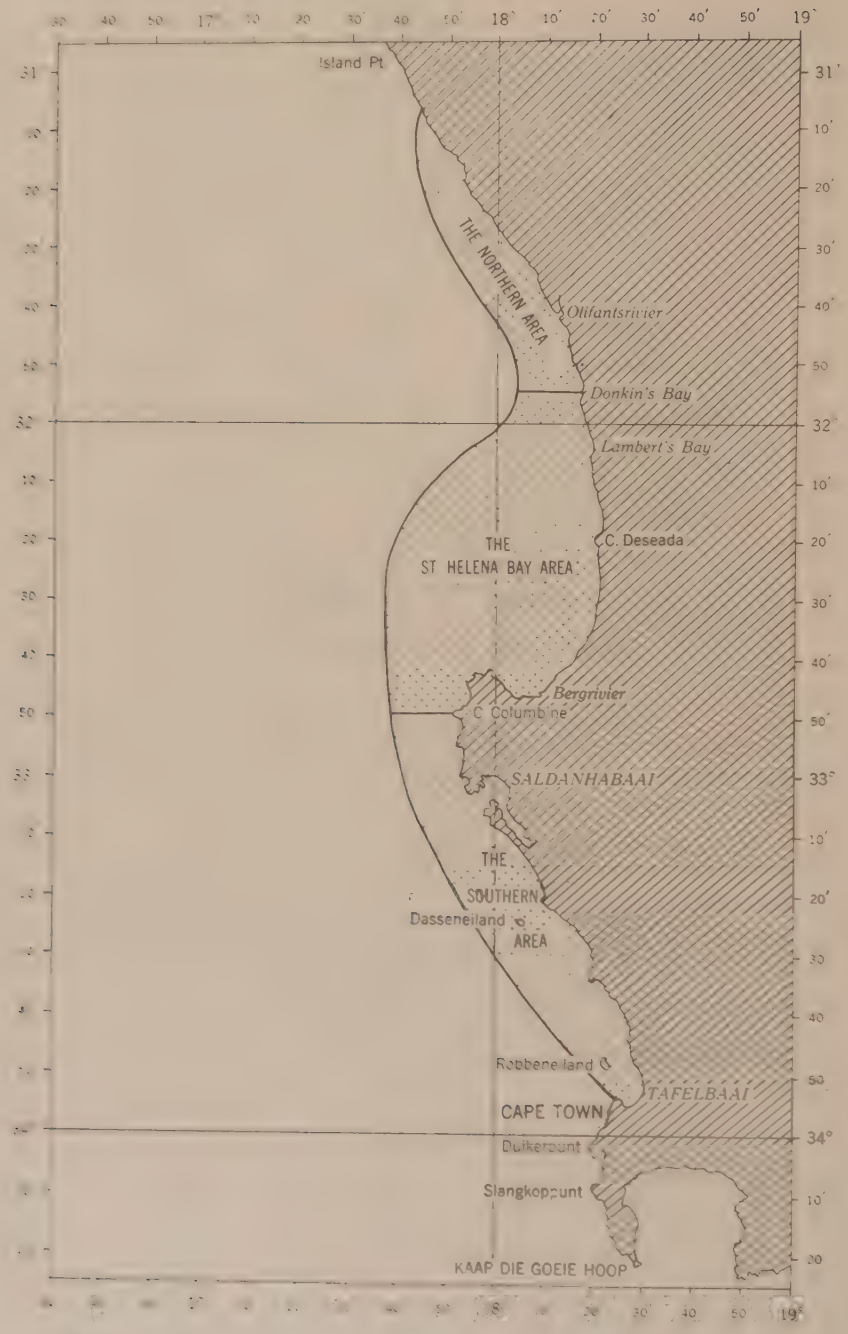


PLATE 1. THE COMMERCIAL FISHING GROUNDS FOR PILCHARDS OFF THE WEST COAST OF THE UNION OF SOUTH AFRICA

Government Printer, 1956.

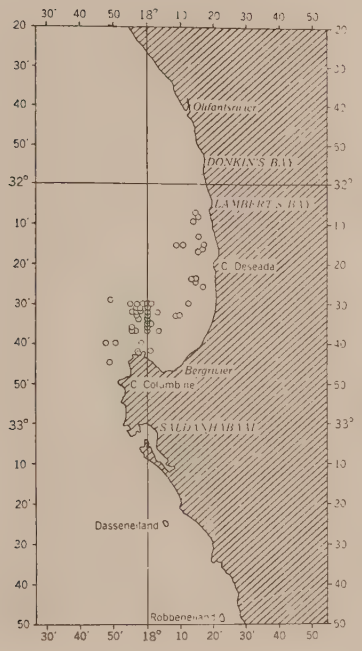


Fig. 1 Autumn

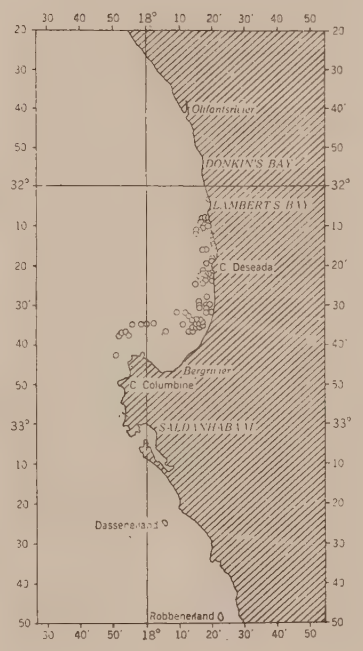


Fig. 2 Winter

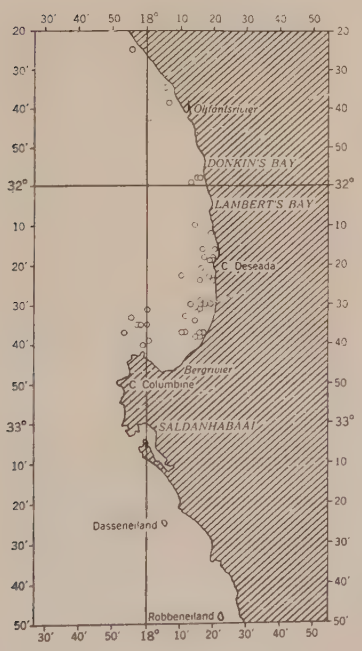


Fig 3 Spring

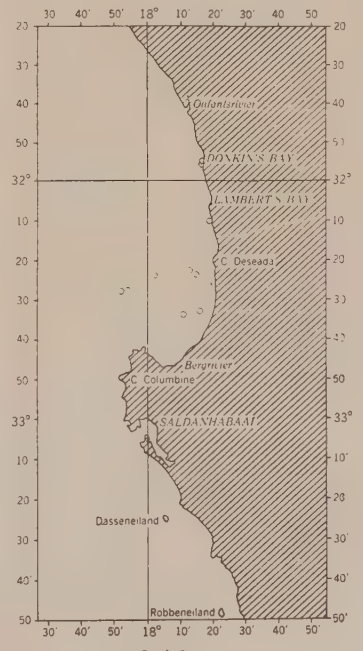


Fig 4 Summer

PLATE 2. COMMERCIAL CATCHES OF PILCHARDS FOR THE YEAR MARCH 1950 TO FEBRUARY 1951

Trigsurvey, 1956

Government Printer 1956

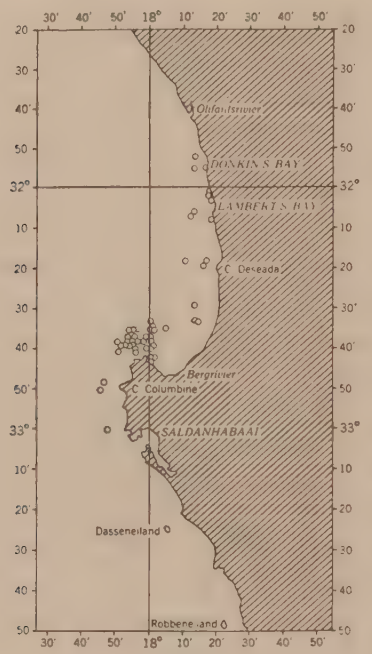


Fig 1 Autumn

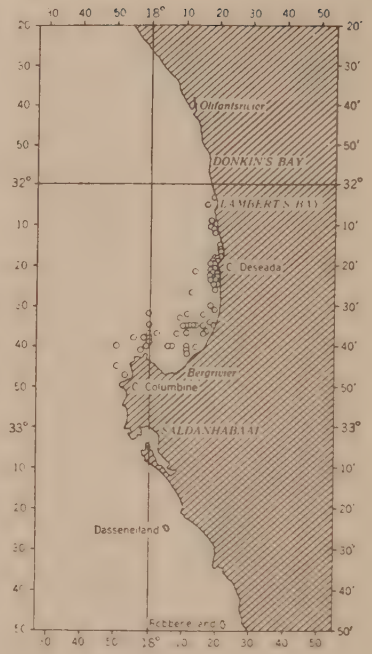


Fig 2 Winter

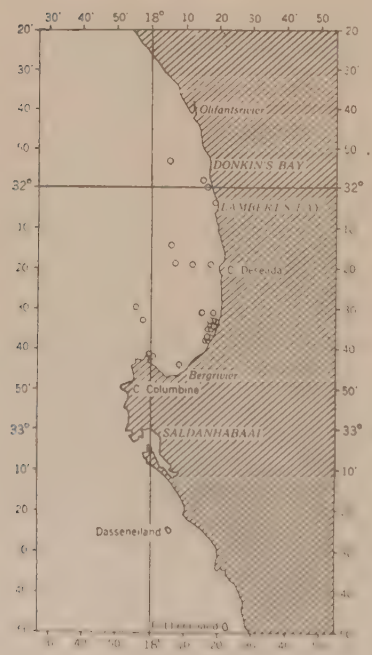


Fig 3 Spring

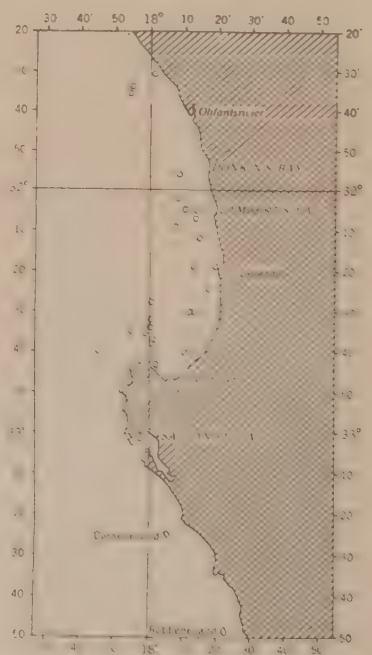


Fig 4 Summer

PLATE 3 COMMERCIAL CATCHES OF PILCHARDS FOR THE YEAR MARCH 1951 TO FEBRUARY 1952

Trigsurvey 1956

Government Printer 1956

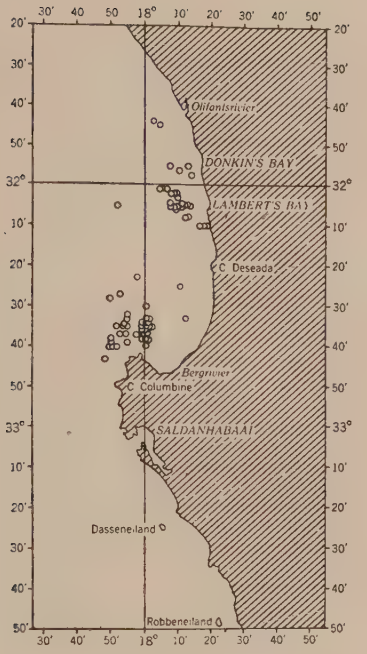


Fig 1 Autumn

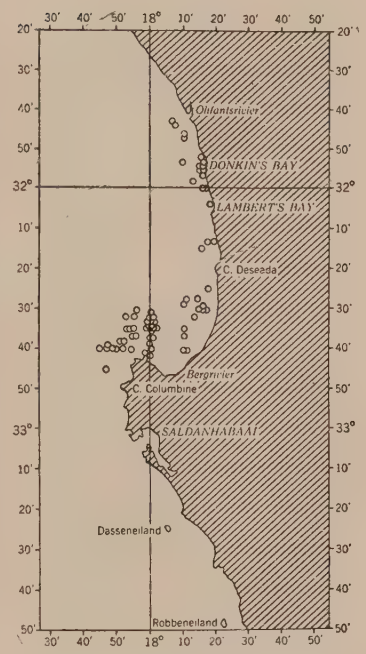


Fig. 2 Winter

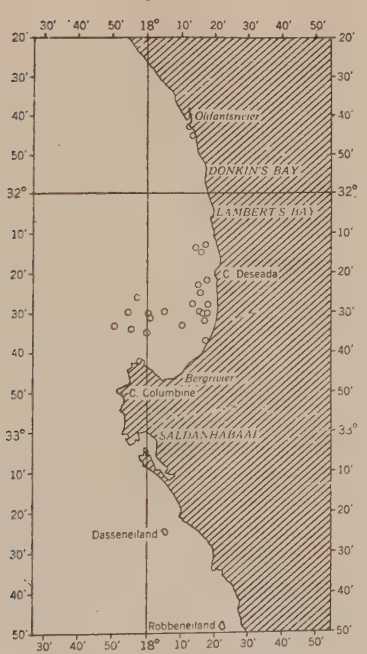


Fig. 3 Spring

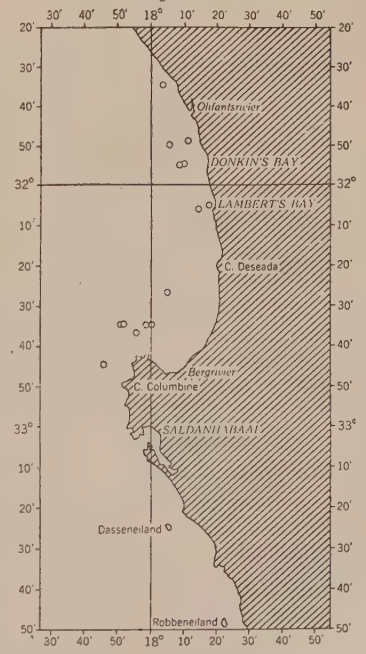


Fig. 4 Summer

PLATE 4 COMMERCIAL CATCHES OF PILCHARDS FOR THE YEAR MARCH 1952 TO FEBRUARY 1953

Government Printer, 1956

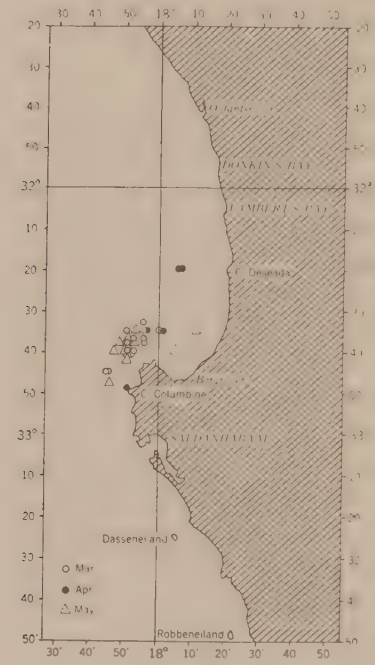
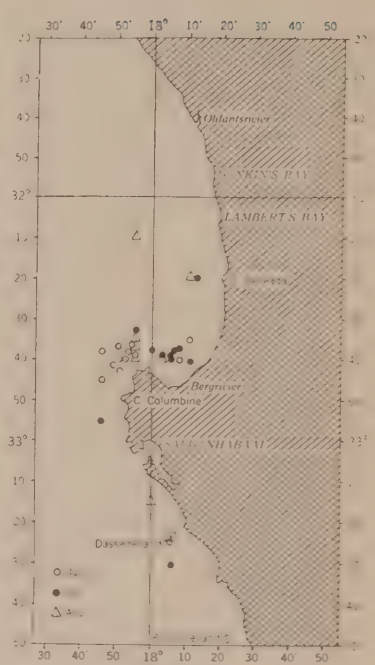


Fig. 1 Autumn



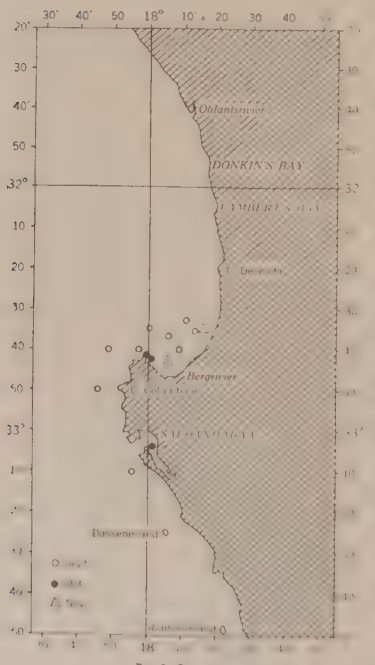


Fig. 3 Spring

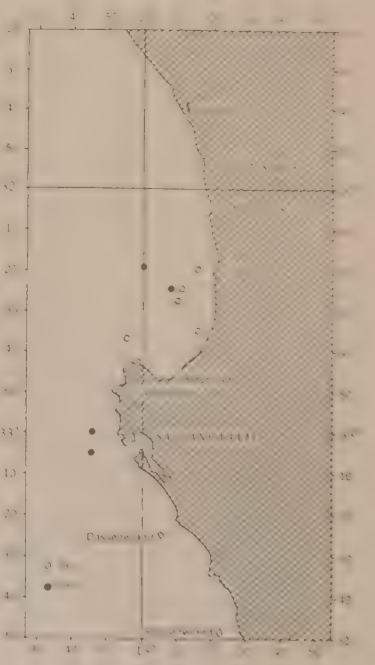


Fig. 4 Summer

PLATE 5 COMMERCIAL CATCHES OF PILCHARDS FOR THE YEAR MARCH 1953 TO FEBRUARY 1954

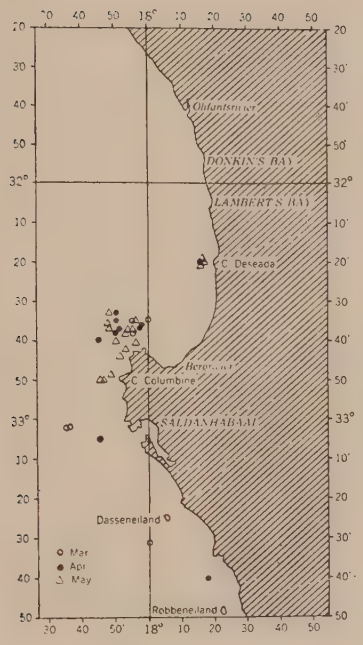


Fig. 1 Autumn

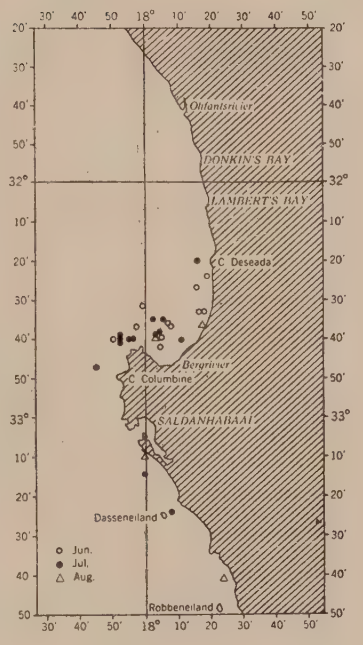


Fig. 2 Winter

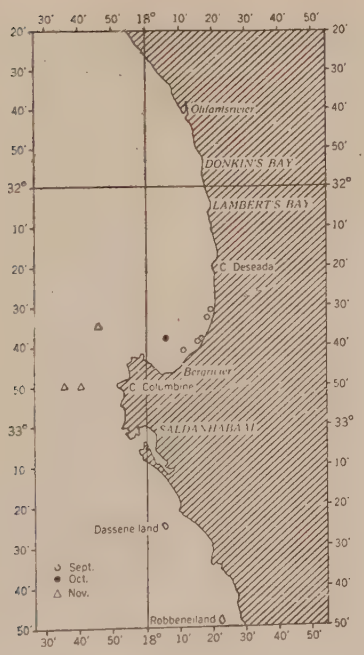


Fig. 3 Spring

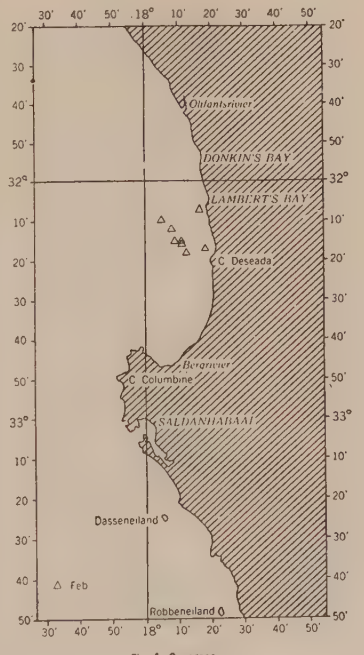


Fig. 4 Summer

PLATE 6. COMMERCIAL CATCHES OF PILCHARDS FOR THE YEAR MARCH 1954 TO FEBRUARY 1955

Trig survey, 1956

Government Printer, 1956

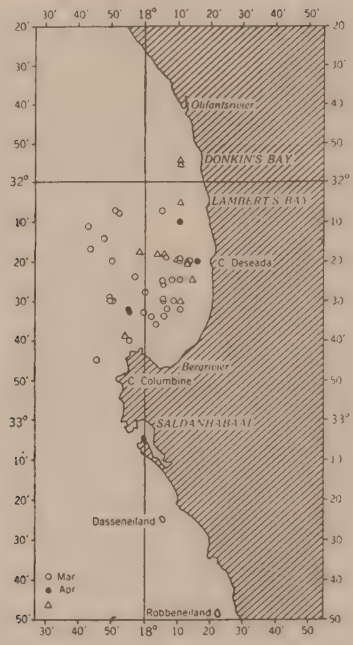


Fig 1 Autumn

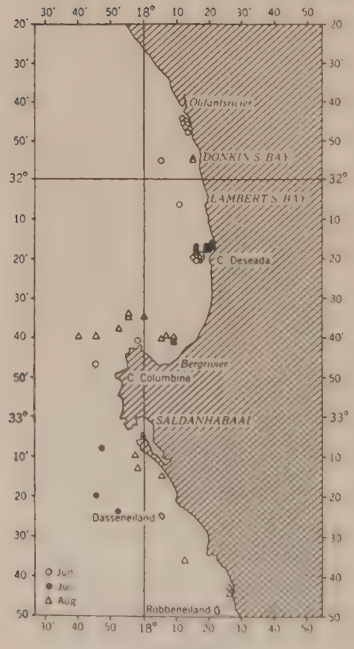


Fig 2 Winter

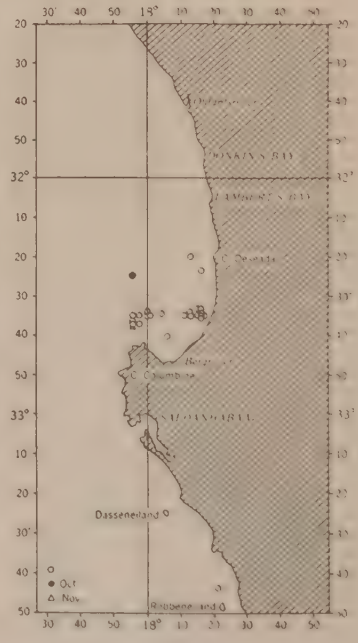


Fig 3 Spring

PLATE 7 COMMERCIAL CATCHES OF PILCHARDS FOR THE PERIOD MARCH 1955 TO NOVEMBER 1955

Trigsurvey, 1956

Government Printer 1956

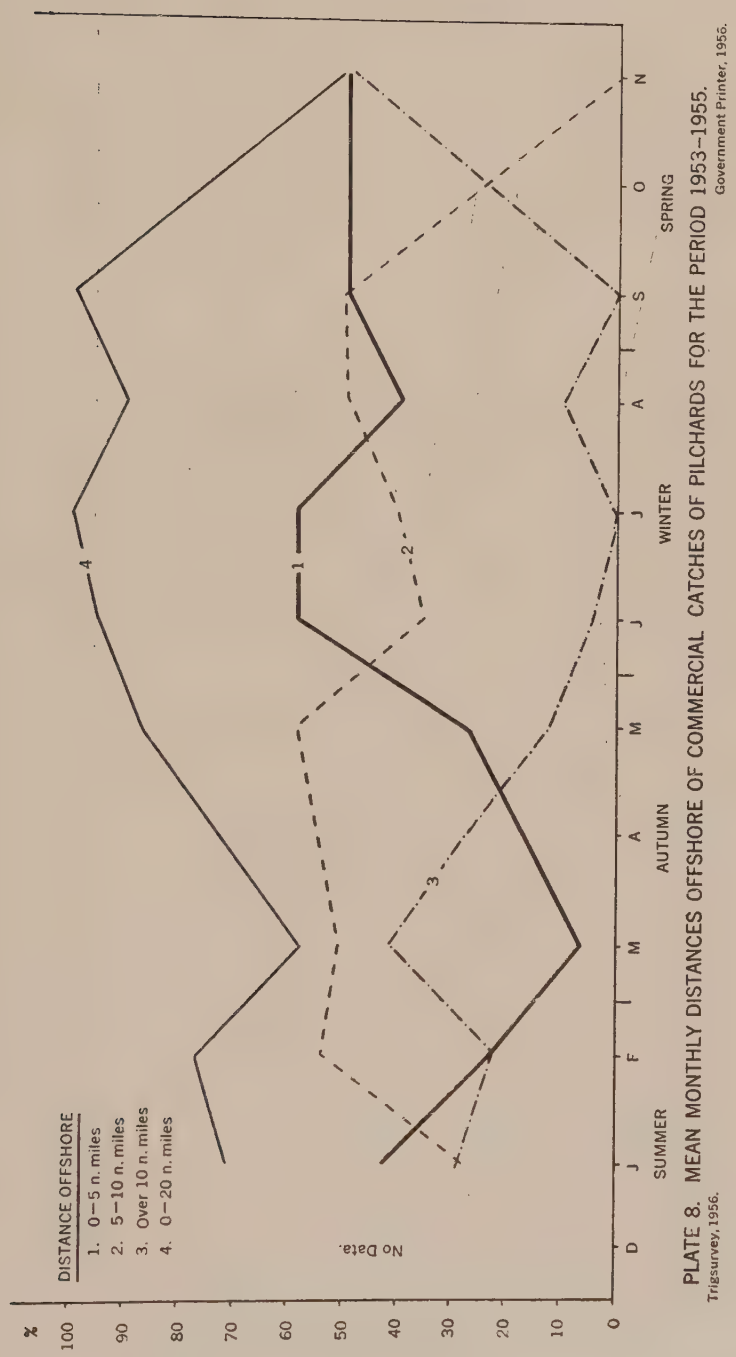


PLATE 8. MEAN MONTHLY DISTANCES OFFSHORE OF COMMERCIAL CATCHES OF PILCHARDS FOR THE PERIOD 1953–1955.

Trigsurvey, 1956. Government Printer, 1956.

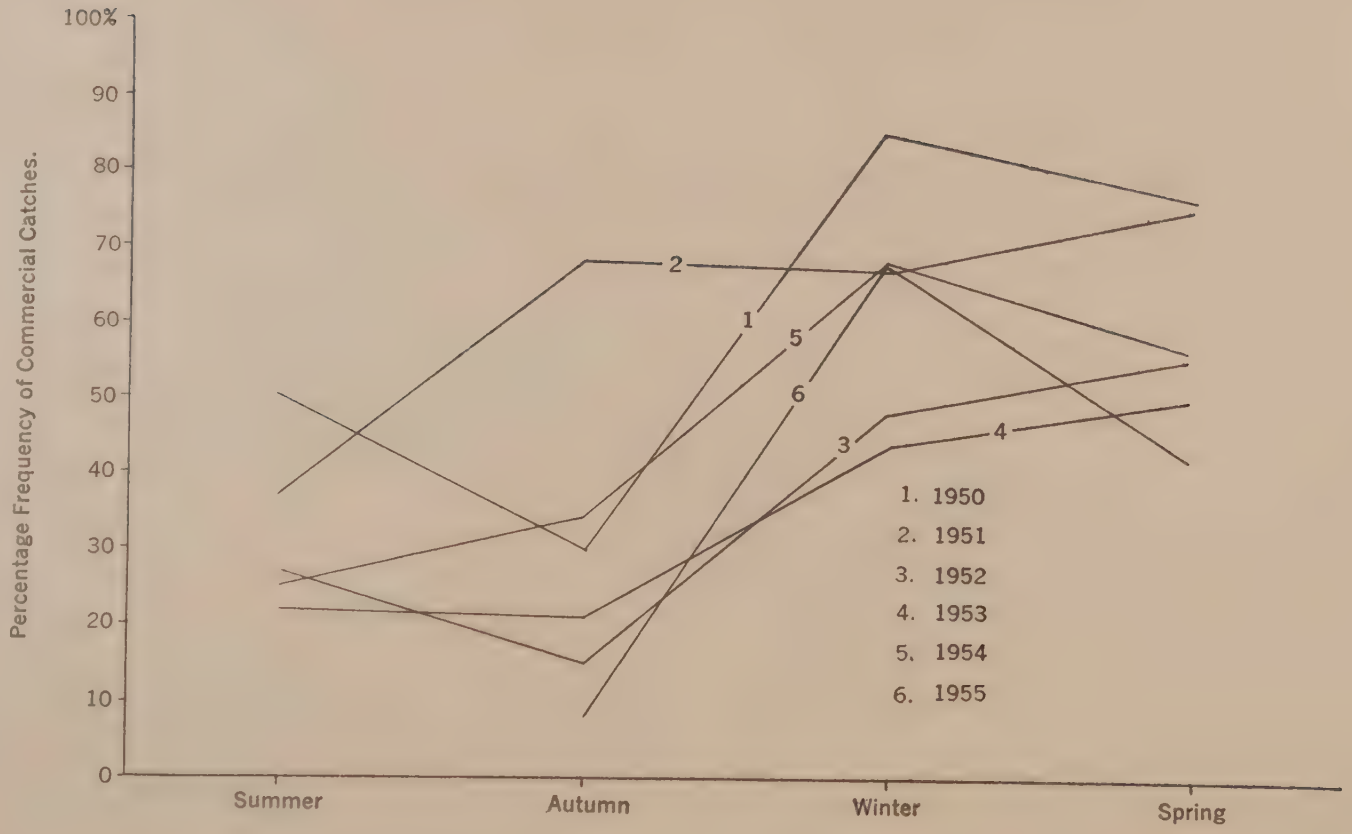


PLATE 9. SEASONAL DISTRIBUTION OF INSHORE (0—5 N. MILES) CATCHES FOR THE YEARS 1950—1955

Trigsurvey, 1956.

Government Printer, 1956.

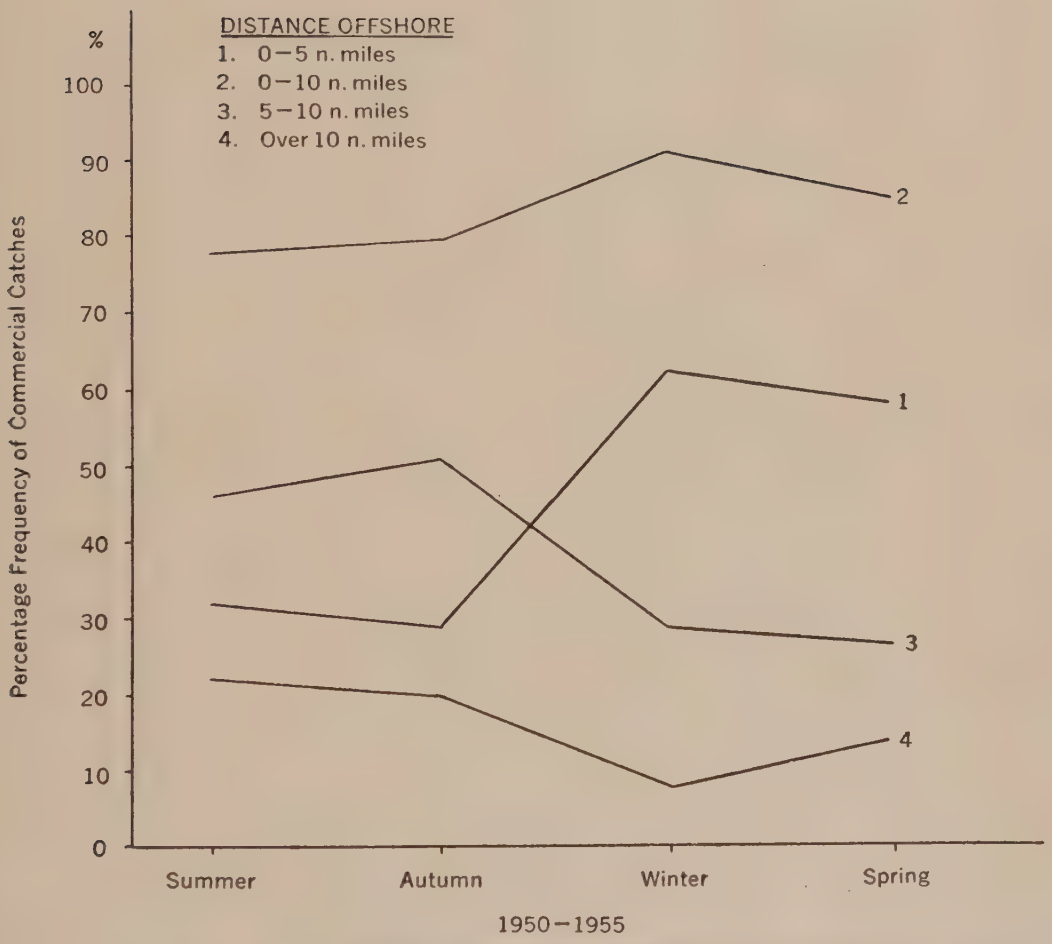


PLATE 10. MEAN SEASONAL DISTANCES OFFSHORE OF COMMERCIAL CATCHES OF PILCHARDS FOR THE PERIOD 1950–1955.

Trigsurvey, 1956. Government Printer, 1956.

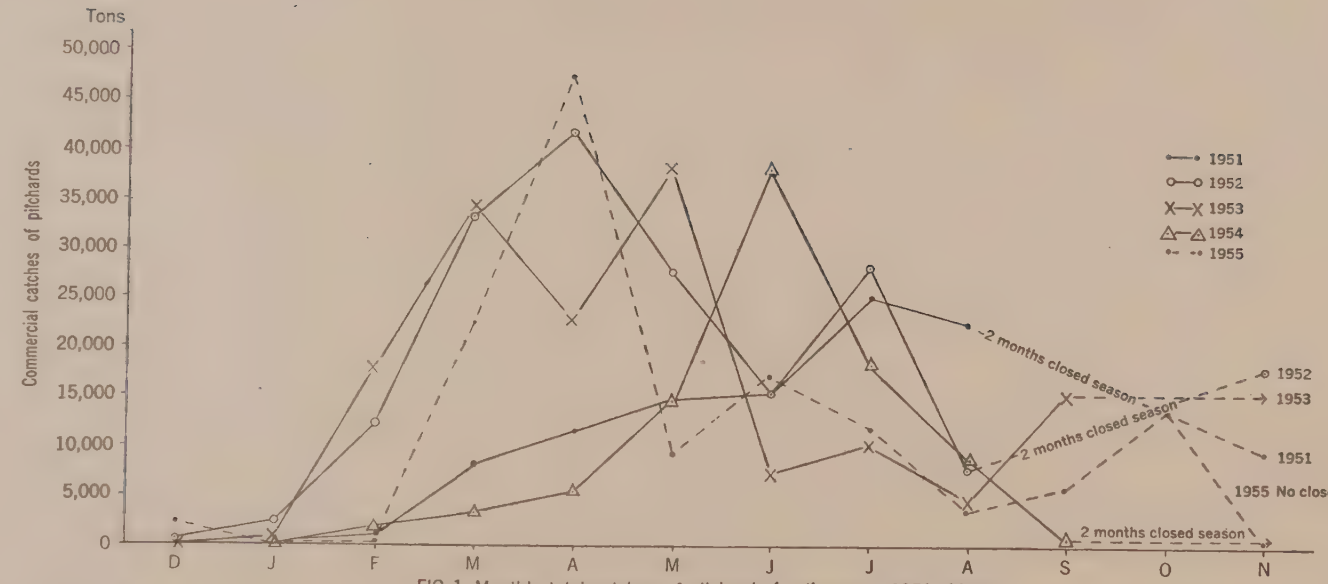


FIG. 1. Monthly total catches of pilchards for the years 1951–1955

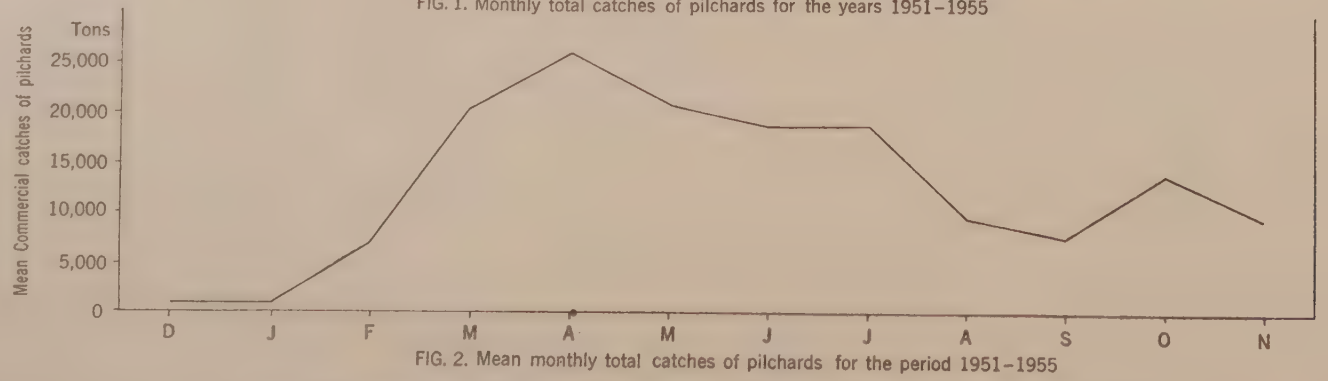


FIG. 2. Mean monthly total catches of pilchards for the period 1951–1955

PLATE 11. COMMERCIAL CATCHES OF PILCHARDS FOR THE UNION OF SOUTH AFRICA, 1951–55

Trigsurvey, 1956.

Government Printer, 1956.

PLATE 12. THE RELATIONSHIP BETWEEN THE MEAN MONTHLY COMMERCIAL CATCHES OF PILCHARDS AND PLANKTON OF THE ST. HELENA BAY AREA.

Trigsurvey, 1956.

Government Printer, 1956.

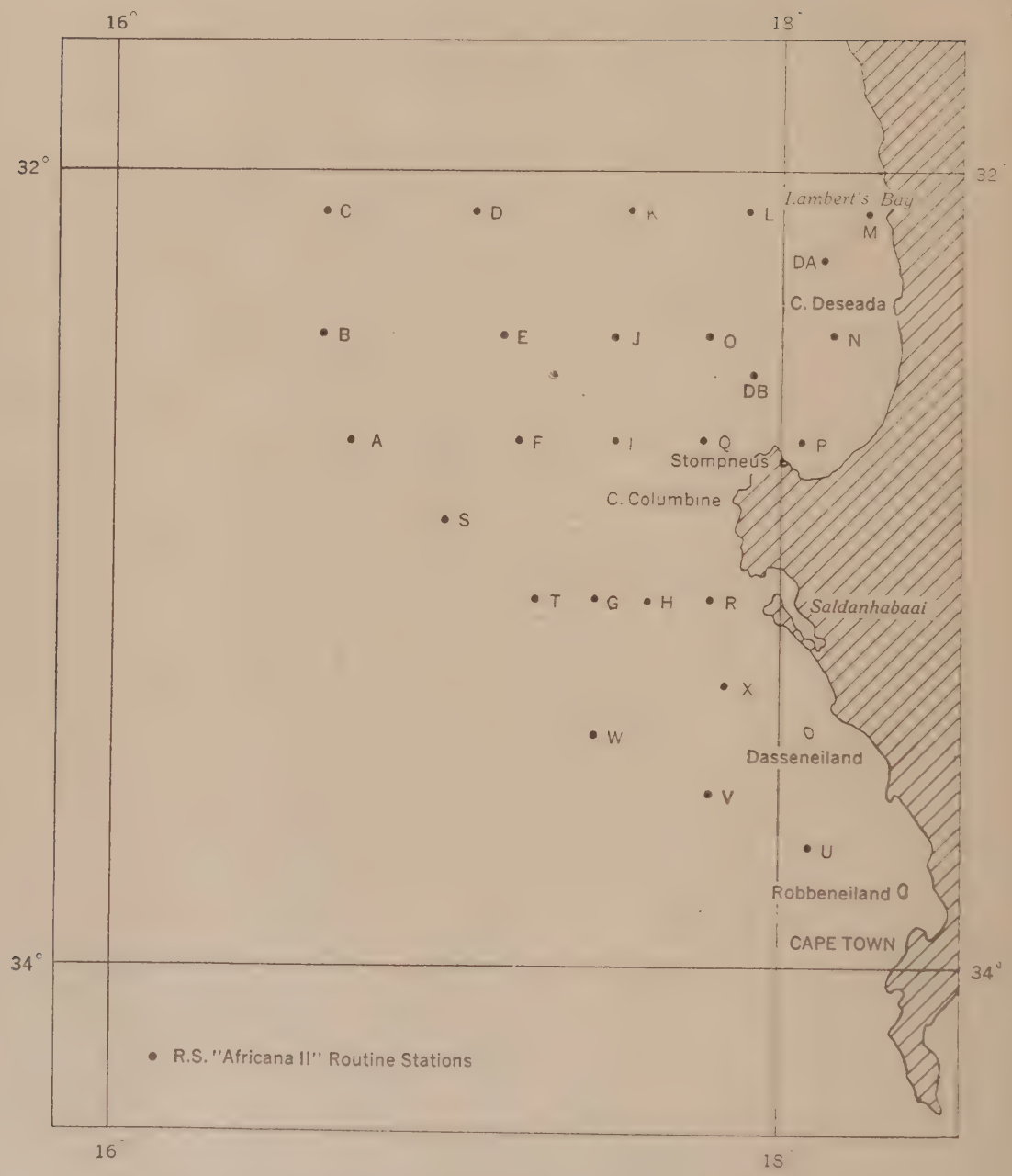


PLATE 13. ROUTINE STATIONS, R.S. "AFRICANA II"

Trigsurvey, 1956.

Government Printer, 1956.

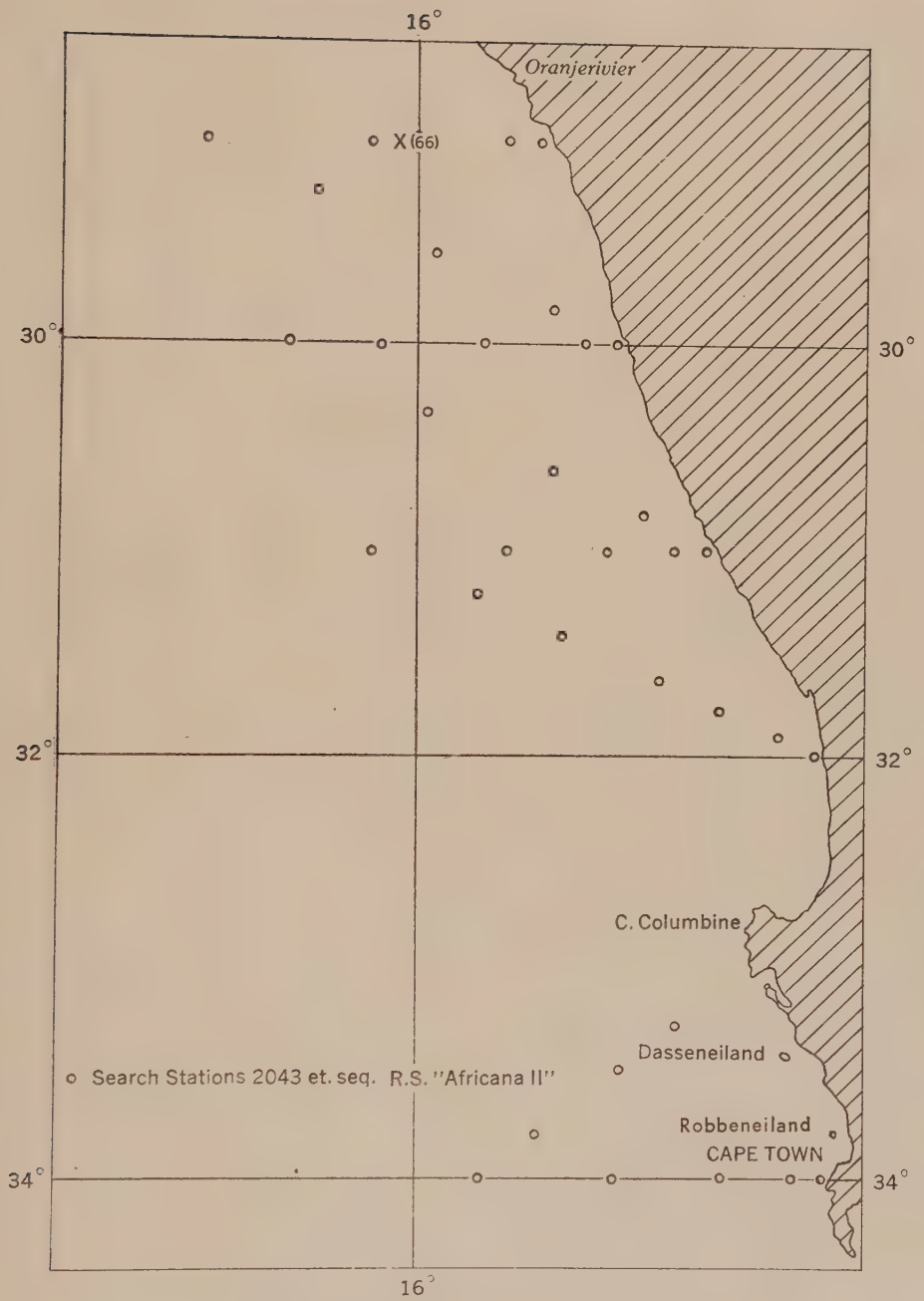


PLATE 14. WEST COAST SEARCH STATIONS, R.S. "AFRICANA II"

Trigsurvey, 1956. Government Printer, 1956.

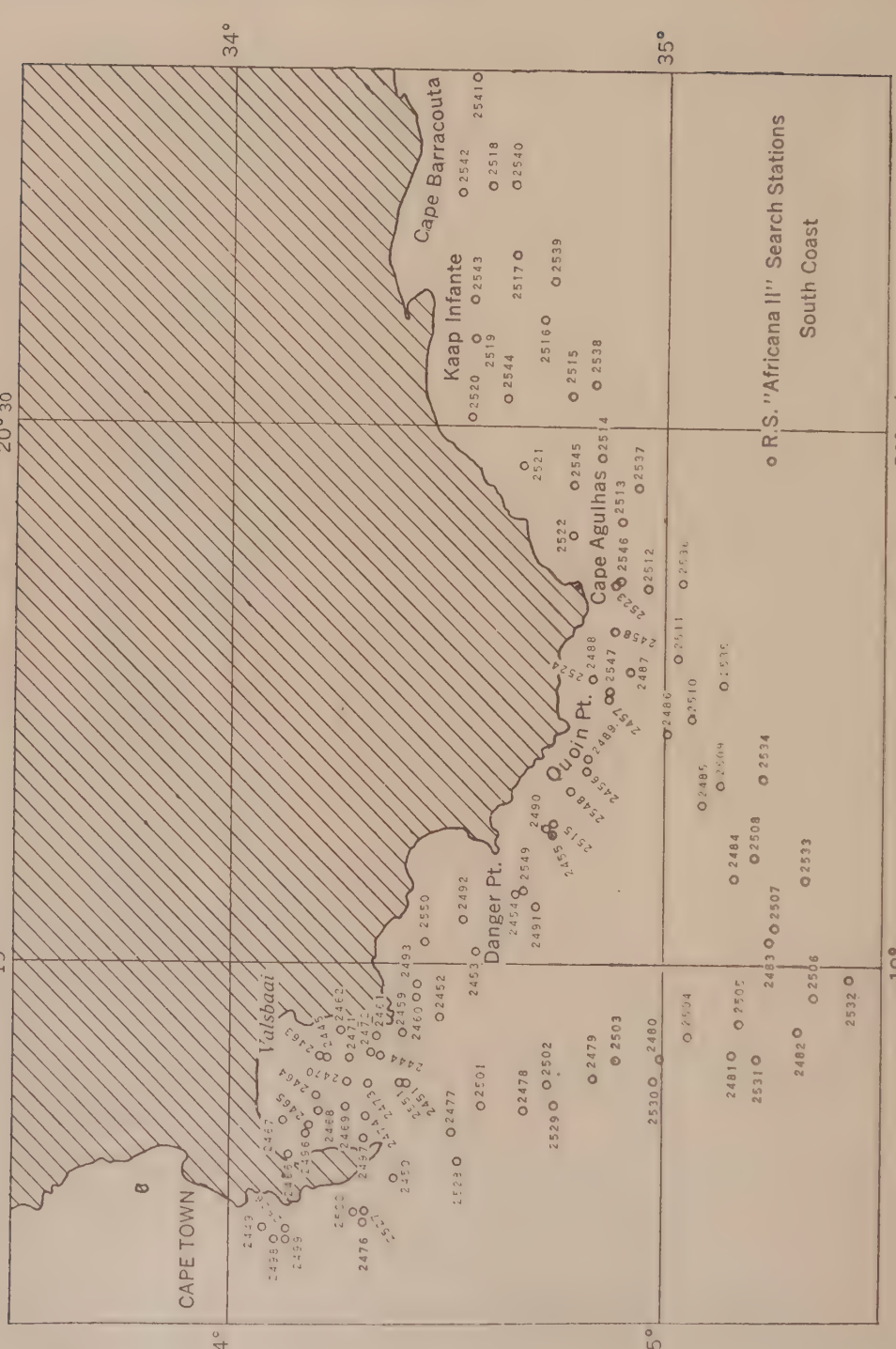


PLATE 15. SOUTH COAST SEARCH STATIONS, R.S. "AFRICANA II"

Trigsurvey, 1956.

Government Printer, 1956.

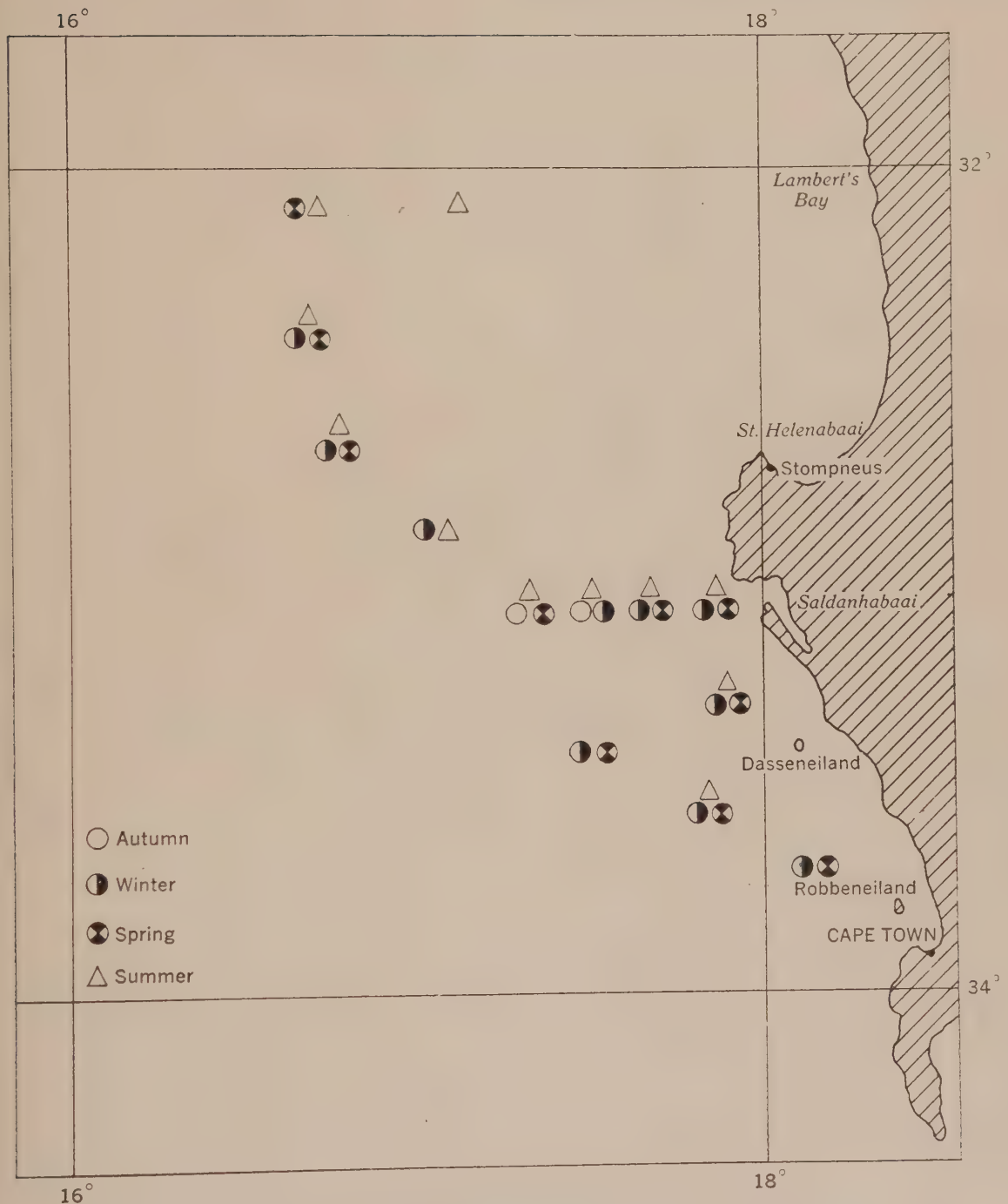


PLATE 16. THE SEASONAL DISTRIBUTION OF PILCHARD OVA OFF THE WEST COAST EXCLUDING THE ST. HELENA BAY AREA.

Trigsurvey, 1956.

Government Printer, 1956.

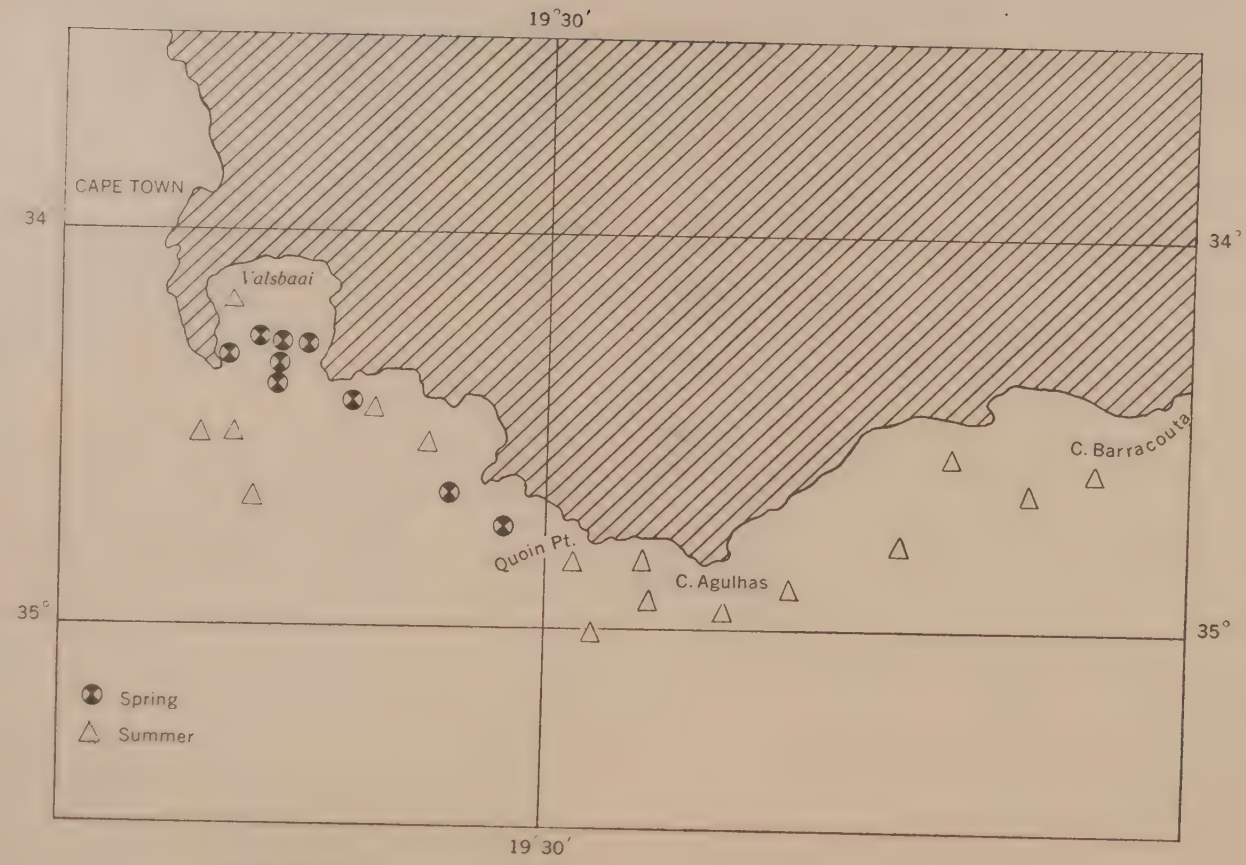


PLATE 17 THE SEASONAL DISTRIBUTION OF PILCHARD OVA OFF THE SOUTH COAST

Trigsurvey, 1956

Government Printer, 1956.

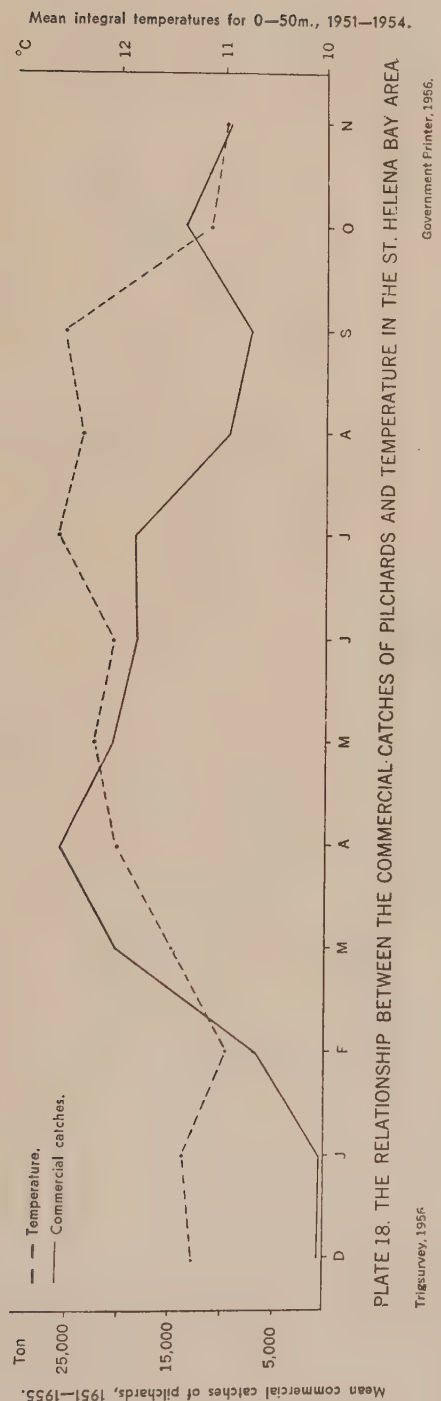


PLATE 18. THE RELATIONSHIP BETWEEN THE COMMERCIAL CATCHES OF PILCHARDS AND TEMPERATURE IN THE ST. HELENA BAY AREA.

Trigsurvey, 1956

Government Printer, 1956.

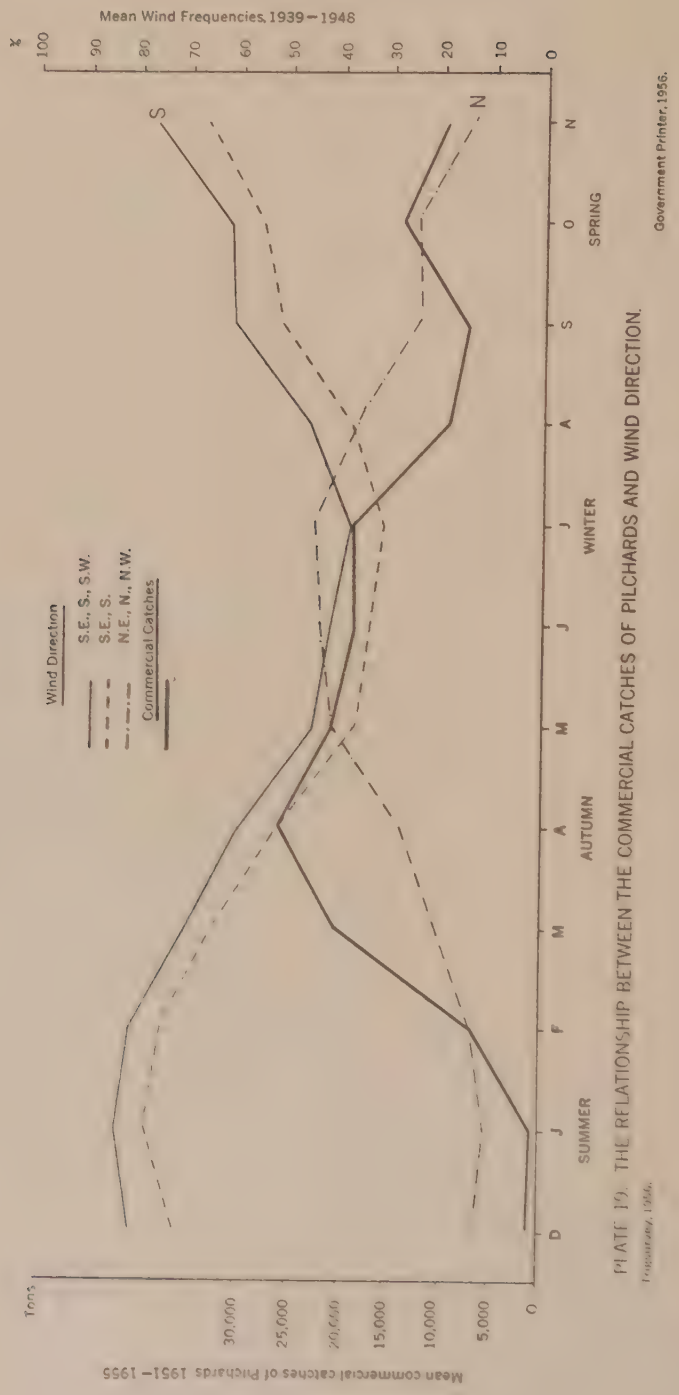


PLATE 19. THE RELATIONSHIP BETWEEN THE COMMERCIAL CATCHES OF PILCHARDS AND WIND DIRECTION.

Government Printer, 1956.

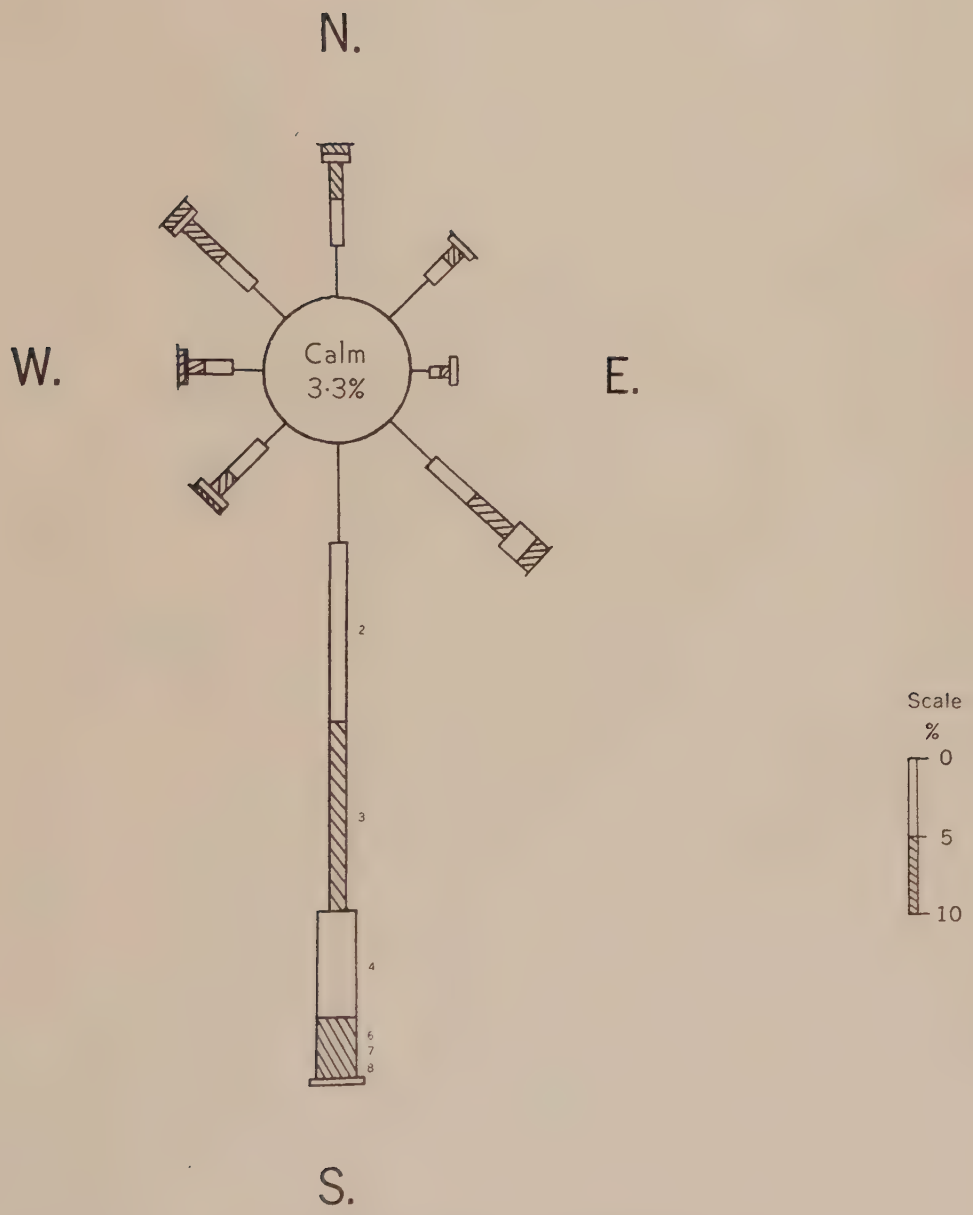


PLATE 20. MEAN WIND VELOCITIES AT CAPE COLUMBINE FOR THE PERIOD 1939—1948
(NUMBERS INDICATE BEAUFORT FORCE)

Trigsurvey, 1956

Government Printer, 1956.

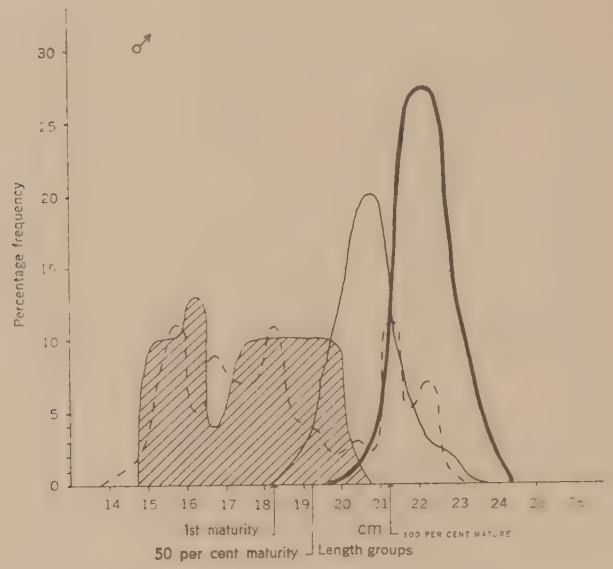


FIG. 1 MALES

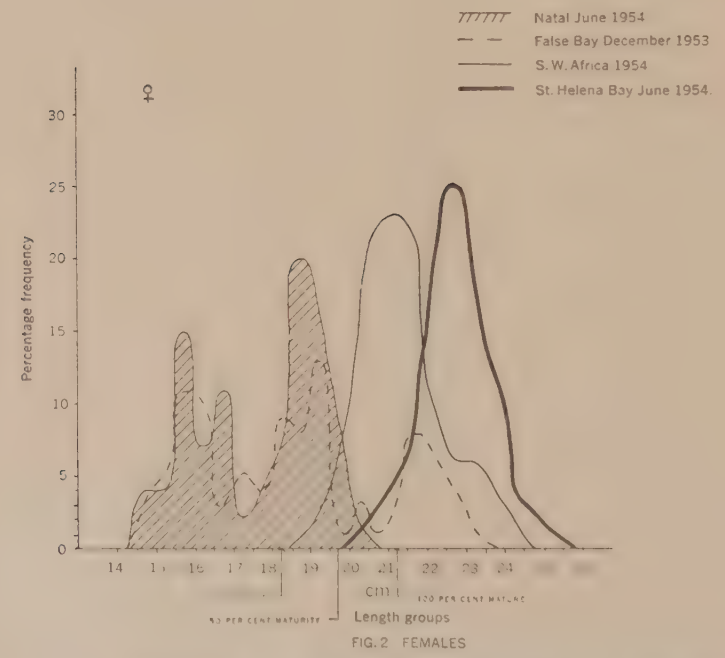


FIG. 2 FEMALES

PLATE 21. COMPARISON OF LENGTH FREQUENCIES OF PILCHARDS FROM COMMERCIAL CATCHES MADE IN NATAL, FALSE BAY, S. W. AFRICA (WALVIS BAY) AND ST. HELENA BAY.

Trigsurvey, 1956. Government Printer, 1956.

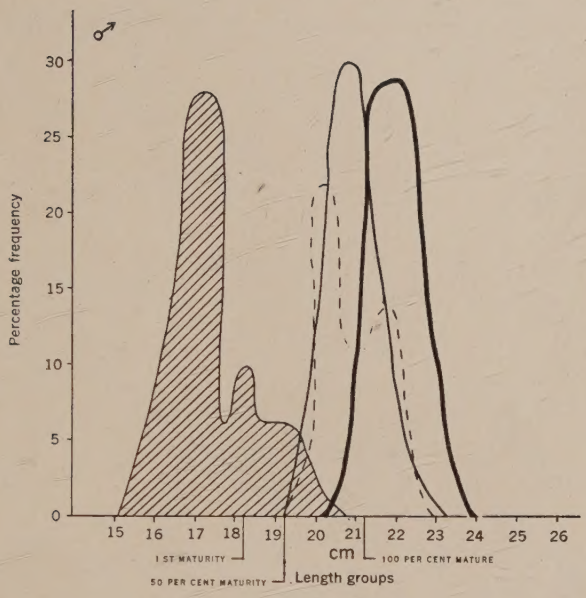


FIG. 1 MALES

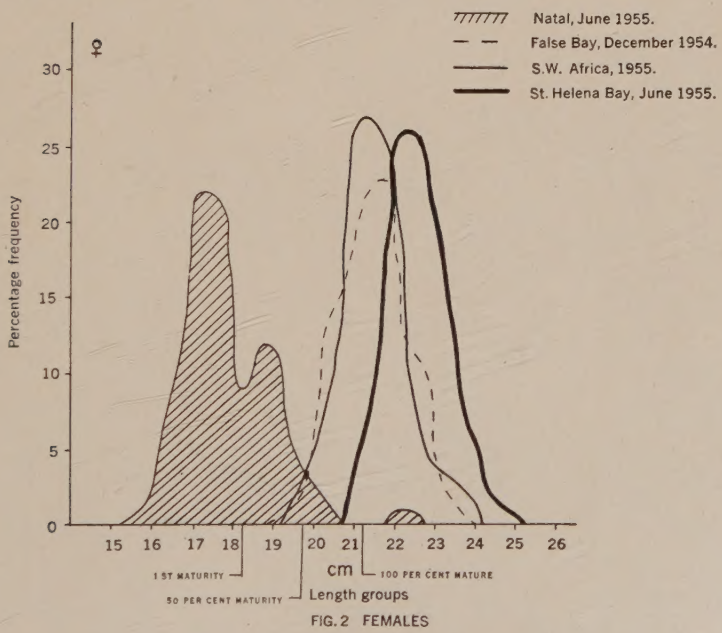


FIG. 2 FEMALES

PLATE 22. COMPARISON OF LENGTH FREQUENCIES OF PILCHARDS FROM COMMERCIAL CATCHES MADE IN NATAL, FALSE BAY, WALVIS BAY (S.W. AFRICA) AND ST. HELENA BAY

Trigsurvey, 1956. Government Printer, 1956.

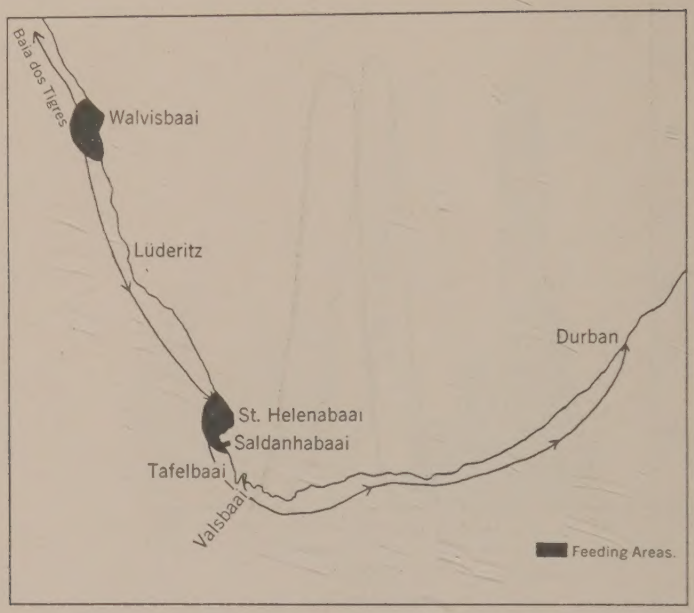


Fig. 1 Feeding Areas and possible migration routes of the Pilchard.

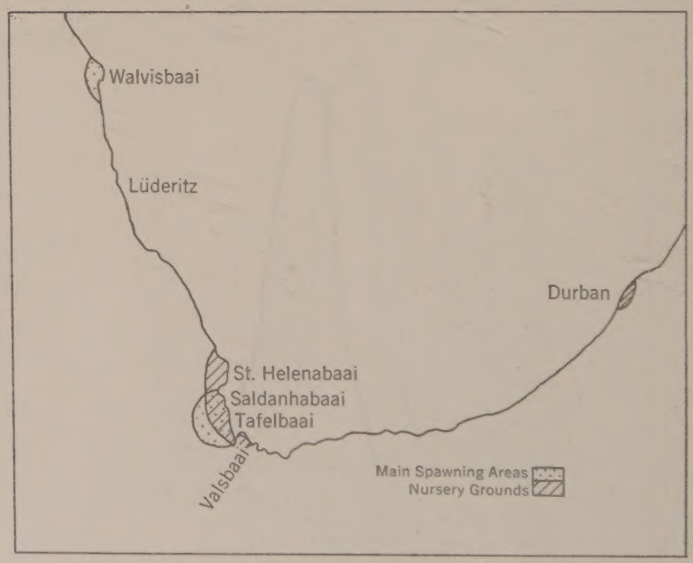


Fig. 2 Main Spawning Areas and Nursery Grounds of the Pilchard.

PLATE 23. THE SOUTH AFRICAN PILCHARD – FEEDING AND SPAWNING AREAS, NURSERY GROUNDS AND POSSIBLE MIGRATION ROUTES.

Trigsurvey, 1956. Government Printer, 1956.